THE OCTOBER SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

CUICUILCO AND THE ARCHAIC CULTURE OF MEXICO. BYRON CUMMINGS 289

THE DUTY OF ASKING QUESTIONS AND THE PRIVILEGE OF DRAWING PICTURES. PROFESSOR H. F. MOORE 305

RACE AND CULTURE. PROFESSOR WILSON D. WALLIS 313

THE INFLUENCE OF THE WEATHER. DR. EDWIN GRANT DEXTER 322

THE TREND OF PUBLIC HEALTH WORK—IS IT EUGENIC OR DYSGENIC? PROFESSOR MAZYCK P. RAVENEL 331

HOW FOSSILS GET INTO THE ROCKS. DR. WENDELL P. WOODRING 337

ARE THE HEAVENS FULL OR ARE THEY VOID? PROFESSOR FLORIAN CAJORI 346

THE RELATION BETWEEN CULTIVATED AREA AND POPULATION. SIR DANIEL HALL 356

POWER RESOURCES OF THE UNITED STATES. HARRISON D. PANTON 366

THE PROGRESS OF SCIENCE:

The Fiftieth Anniversary Meeting of the American Chemical Society and the Progress of Chemistry in America: DR. E. E. SLOSSON 372

THE SCIENCE PRESS

LANCASTER, PA.—GRAND CENTRAL TERMINAL, N. Y. CITY—GARRISON, N. Y.

Yearly Subscription $5.00 Single Copies 50 cents

NEW FEATURES

of the 1927 model

B & L MICROSCOPE FFS-8

Graduated Fine Adjustment—Reads 2.5 microns movement for each space on head.

Divisible Abbe Condenser—Top lens removable to insure evener illumination in low power work.

Improved Screw Substage Construction—Maintains centering of condenser while retaining swing out feature.

Standardized Objective Mountings—Insuring correct centering and parfocal conditions.

Correct Tube Length indicated at 160 mm mark by line completely encircling draw tube.

Bausch & Lomb Optical Co.

633 St. Paul St., Rochester, N. Y.

For the Scientific Reader

E. E. Slosson recommends one of our new books for wide sale.

THE NATURE OF THE WORLD AND OF MAN

By SIXTEEN MEMBERS OF THE UNIVERSITY OF CHICAGO FACULTIES

He writes in *Science Service:* "Those who have not had the advantage of a collegiate education will find here the means of making up in a measure for what they have missed, a knowledge of the world about them interpreted by contemporary thought. Those who have studied certain of the sciences some years ago will find this volume useful in freshening up their views."

The Nature of the World and of Man is a co-operative survey of all science, an outline of our knowledge of the physical and biological world, and man's relative position in it. It is designed to give a preliminary view of many rich intellectual fields, all marshalled together to assist the individual in the important problem of forming a well-defined conception of the cosmos and his relation to it.

$4.00, postpaid $4.15

STUDIES IN OPTICS

By A. A. MICHELSON

In his book Professor Michelson describes in detail the methods used in his more important experiments, and speaks also of other applications of the interferometer. All of his important researches have turned on the subject of light, and this volume on optics is an important contribution to the field.

$2.00, postpaid $2.10

LABORATORY OUTLINES IN BACTERIOLOGY AND IMMUNOLOGY

By JOHN F. NORTON and I. S. FALK

Exercises designed to acquaint the student with a variety of the best methods, to give him practice in working with different groups of bacteria, and to illustrate types of immunologic phenomena.

$2.00, postpaid $2.10

A LABORATORY OUTLINE FOR ELEMENTARY ZOOLOGY (Revised)

By LIBBIE H. HYMAN

With three additional chapters on echinodermata, mollusca, and a teleost fish respectively, as complete a survey of the animal kingdom as is desirable for an elementary course is now available in this book.

$2.50, postpaid $2.60

Charles H. Judd says in the Elementary School Journal:

"It is a book which no advanced student of human nature can afford to overlook."

BRAINS OF RATS AND MEN

By C. JUDSON HERRICK

Objective behavior and subjective experience are here reformulated in biological terms. Dr. Herrick demonstrates incisively that the entire intellectual, emotional, and moral life of mankind can be explored as biological functions without loss of their supreme values as distinctively human attributes.

Others have tried to read human faculties backward into lower animals. Dr. Herrick reverses the order and, beginning with the simplest structures prophetic of cerebral cortex, he reads this history through to its culmination in man.

Brains of Rats and Men, by one of America's foremost neurologists, touches upon problems that are fundamental to all the sciences that take living things, and man in particular, as their province; and it belongs to that rare class of scientific writing of genuine literary merit.

$3.00, postpaid $3.15

At all dealers or from

THE UNIVERSITY OF CHICAGO PRESS

5811 Ellis Avenue Chicago, Illinois

Vol. XXIII, No. 4 Whole No. 133

The Scientific Monthly

An Illustrated Magazine Devoted to the Diffusion of Science

Edited by J. McKEEN CATTELL

October, 1926

Published by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.

New York, N. Y., Grand Central Terminal

Single Number, 50 Cents

Yearly Subscription, $5.00

COPYRIGHT 1926 BY THE SCIENCE PRESS

Entered as second-class matter at the post office at Lancaster, Pa., July 18, 1923, under the Act of March 3, 1879.

University of

CALIFORNIA PRESS

CONTRIBUTIONS TO

TROPICAL PHYSIOLOGY

WITH SPECIAL REFERENCE TO THE ADAPTION OF THE WHITE MAN TO THE CLIMATE OF NORTH QUEENSLAND.

By E. S. SUNDSTROEM.

Townsland, North Queensland, situated 19 degrees south on the coastal belt of the Australian tropics, is the largest tropical community on the earth inhabited by a pure white race, an almost homogeneous transplantation of Anglo-Saxon and Saxon stock. Besides, this population is a working one, even the most menial occupations being in the hands of whites.

216 large octavo pages. $2.50

University of California Press

Berkeley, California

MODERN BIOLOGY:

Its Human Aspects

By HARRY DWIGHT WAGGONER

Presenting Biological Facts Centering on the Nutrition and Welfare of the Human Body

This book will serve as an eye-opener to those just beginning to blink at the complexities of the science of living things. Every fact included or excluded by the author was tested for its influence and importance in human life. Man himself, with his body and its nutrition and heredity, is placed in the middle of the road in this course for high school students, and plant life and animal life, so far as they affect human welfare, are searched for contributory information. Although intended primarily as a textbook, it would give any general reader anxious to be enlightened an enjoyable liberal education in the biological sciences. List price, $1.96.

Bennett's *Laboratory Manual* to accompany Waggoner's *Modern Biology* is now ready.

D. C. HEATH AND COMPANY

Boston New York Chicago Atlanta

Dallas San Francisco London

SURFACE EQUILIBRIA OF BIOLOGICAL AND ORGANIC COLLOIDS

BY

P. LECOMTE DU NOÜY, D.Sc.

WITH INTRODUCTIONS BY

DR. ALEXIS CARREL AND PROF. ROBERT A. MILLIKAN

A. C. S. MONOGRAPH NO. 27

TABLE OF CONTENTS

CHAPTER 1. TECHNIQUE
Introduction. The Tensiometer. Standardisation. Absolute Measurements. Relative Measurements. Preparation of the Glasses. Wetting of the Glass. Preparation of the Solutions. Experimental Set-up.

CHAPTER 2. DROP OF THE SURFACE TENSION OF COLLOIDAL SOLUTIONS AS A FUNCTION OF TIME
Technique. Application of the study of serum solutions and sodium oleate. Action of Stirring. Action of Heat on the Surface Tension of Serum. Influence of Gases on the Surface Tension of Serum Solutions.

CHAPTER 3. MONOMOLECULAR LAYER OF SERUM CONSTITUENTS
Adsorption on the Glass. Percentage of Proteins in Rabbit Serum. Specific Gravity of Anhydrous Proteins. Calculation of the thickness of the monolayer. Significance of the Critical Concentration.

CHAPTER 4. SODIUM OLEATE
Dimensions of the Molecule. Calculation of the Constant *N* of Avogadro. Discussion of the Errors.

CHAPTER 5. EGG ALBUMIN
Study of the Egg Albumin Molecule. Dimensions. Molecular weight.

CHAPTER 6. CHARACTERISTICS OF IMMUNE SERUM

CHAPTER 7. INFLUENCE OF COLLOIDS ON THE CRYSTALLIZATION OF SODIUM CHLORIDE
Aspects of Crystals after evaporation. Aspects of Crystals at the Critical Concentration: 1. Sodium Oleate Monolayers. 2. Immune Serum.

CHAPTER 8. SURFACE EQUILIBRIUM OF COMPLEX COLLOIDAL SOLUTIONS
Antagonistic Effect—A highly sensitive Method for detecting Proteins and Colloidal Particles in a Solution.

CHAPTER 9. INTERFACIAL TENSION. INSTRUMENT—RESULTS—TEMPERATURE COEFFICIENT—ADSORPTION AT INTERFACES AS A FUNCTION OF TIME. SURFACE VISCOSITY.—ITS INCREASE WITH TIME

CHAPTER 10. COLLOIDALITY OF SOLUTIONS OF PROTEINS, SERUM AND PLASMA

CHAPTER 11. GENERAL CONCLUSIONS

212 Pages **Illustrated** **Price $4.50**

Now Ready

BOOK DEPARTMENT

The CHEMICAL CATALOG COMPANY, *Inc.*

19 EAST 24th STREET, NEW YORK, U. S. A.

Two Standard Works on Chemistry

A Comprehensive Treatise on Inorganic and Theoretical Chemistry

By J. W. MELLOR

Author of "Modern Inorganic Chemistry," "Introduction to Modern Inorganic Chemistry," "Higher Mathematics for Students of Chemistry and Physics," "The Crystallization of Iron and Steel," etc. The work consists of Royal 8vo. volumes, each containing about 1,000 pages, the page of type being 7¾ ins. by 4¾ ins., fully illustrated, mainly from original drawings.

Vol. I.	H, O.	$20	Published
Vol. II.	F, Cl, Br, I, Li, Na, K, Rb, Cs.	$20	Published
Vol. III.	Cu, Ag, Au, Ca, Sr, Ba.	$20	Published
Vol. IV.	Radium Family, Actinium Family, Beryllium, Magnesium, Zinc and Cadmium, Mercury.	$20	Published
Vol. V.	B, Al, Ga, In, Tl, Sc, Rare Earths, C.	$20	Published
Vol. VI.	C (Part II), Si, Silicates.	$20	Published
Vol. VII.	Ti, Zr, Hafnium Th, Ge, Sn, Pb, Inert Gases.		In the Press

"The first impression, which appears to be almost universal, is one of amazement and admiration that any one individual should undertake and be able to carry on such a tremendous task as the compilation of this treatise. . . . The reviewer is glad to add his tribute to the courage, industry, and wide knowledge which the author has displayed. . . . The work is unquestionably the most complete source of information existing in English, and the remaining volumes will be awaited with great interest."—*Journal of Industrial and Engineering Chemistry.*

"As a reference book for studying the development of any subject in inorganic chemistry it is accurate and complete. It will undoubtedly have its greatest use in that capacity although we commend it most heartily to serious students of inorganic chemistry who desire to obtain a comprehensive idea of the subject."—*Chemical and Metallurgical Engineering.*

"A 'Comprehensive Treatise' undoubtedly represents a most important contribution to chemical literature, and one that will prove invaluable to the investigator as a source of information and suggestion, and to the advanced student and teacher as a source of 'outside reading' which will prove interesting and valuable.

"The remaining volumes of the series will be awaited with much interest."—*Science.*

A Dictionary of Applied Chemistry

By SIR EDWARD THORPE, C.B., LL.D., F.R.S.

Emeritus Professor of General Chemistry and Director of the Chemical Laboratories of the Imperial College of Science and Technology, South Kensington, London.

Assisted by Eminent Contributors.

New edition. Revised and enlarged.

Vol. I.	A to CALCIUM	$20	Published
Vol. II.	CALCULI to EXPLOSION	$20	Published
Vol. III.	EXPLOSIVES to KYROFIN	$20	Published
Vol. IV.	L to OXYDISILIN	$20	Published
Vol. V.	OXYGEN to RYE	$20	Published
Vol. VI.	S to TETRYL	$20	Published
Vol. VII.	THALENITE to Z, with a Full Index to the Complete Work		In the press

"The names of the various writers are sufficient guarantee of its general excellence. . . . The work as a whole is beyond criticism, and the new edition deserves a place on the bookshelf of every technical chemist. . . ."—*The Analyst.*

"Sir Edward Thorpe's comprehensive dictionary, with its world-wide reputation, may truly be described as a 'magnum opus' from every standpoint. Not only is it a great work from the point of view of bulk, but it provides a wonderful source of information on every conceivable branch of technical chemistry."—*Chemical Age.*

Send for Science Catalogue

LONGMANS, GREEN & CO.

55 Fifth Avenue **New York**

P. BLAKISTON'S SON & CO., Publishers

1012 WALNUT STREET :: :: PHILADELPHIA

Good Health Magazine.

"It is admirably adapted to the needs of the intelligent layman who frequently runs across medical terms which are not easily understood. The selection of subjects treated has been made with such care that room has been found for everything really essential to a volume of this sort."

Pocket Cyclopedia
Of Medicine and Surgery

3rd Edition. Revised, Enlarged

Flexible Binding $2.50. Thumb Index $3.00

Edited by

R. J. E. SCOTT, M.A., B.C.L., M.D. (New York)

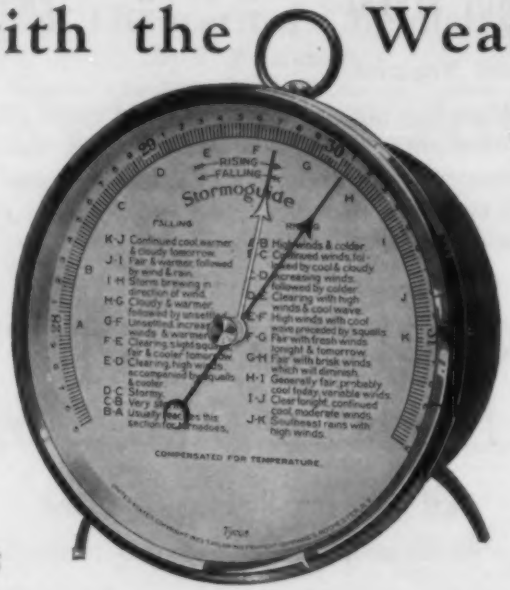
THE plan of this work is to explain briefly and clearly the essential facts of medicine and related sciences. Each article covers the points that are of general interest with the aim to present the most recent advances.

Certain subjects are tabulated for greater convenience; among these are tables of nerves, muscles, solutions, reflexes, weights and measures, dose-lists, etc.

Many of the terms explained in this volume cannot readily be found elsewhere; the book, therefore, fills a very definite place in the way of serviceableness.

The subjects are arranged in alphabetical order with numerous cross-references which greatly aid in finding the topic sought.

Plan Your Pleasure with the Weather



Price
$25.00

USE a
Tycos
STORMOGUIDE

FRESH breezes for that sailing trip or squall-lashed waters—a day of golf or rain-swept links? Watch the Stormoguide. It will tell you 12 to 24 hours in advance. Do not depend on ancient proverbs or the appearance of the sky, but find out from a Stormoguide what actually is forecast to occur.

Tycos Stormoguides are reliable barometers, with real weather information printed on the dial instead of the misleading, "Rain," "Change," and "Fair," on the dials of ordinary barometers.

They make excellent gifts for any occasion. Especially suitable for golf clubs and out-of-door people. Get one for your home and suit your pleasure to the weather.

Stormoguide illustrated has a 5" silvered metal dial, round brass case, folding feet, and is compensated for temperature and adjustable for altitude. A very superior instrument in every way. Price $25.00. Other models from $18.00 to $50.00.

See them at any good instrument dealer. If he is not supplied, write direct to us, enclosing correct price, and we will fill the order. Safe delivery guaranteed. Stormoguide Booklet sent upon request.

Taylor Instrument Companies

ROCHESTER, N. Y., U. S. A.

Canadian Plant Tycos Building, Toronto
Manufacturing Distributors in Great Britain: Short & Mason, Ltd., London

NEW McGRAW-HILL BOOKS

Fath—
ELEMENTS OF ASTRONOMY

By **Edward Arthur Fath**, Professor of Astronomy in Carleton College. 307 pages, 6 x 9, 191 illustrations. **$3.00**

A non-mathematical textbook for use as an introduction to the subject in colleges, universities, etc., and for the general reader.

Shull—
HEREDITY

By **A. Franklin Shull**, Professor of Zoology in the University of Michigan. *McGraw-Hill Publications in the Zoological Sciences.* 287 pages, 6 x 9, illustrated. **$3.00.**

This book presents the principles and problems of biological inheritance in reference, for the most part, to matters of human interest.

Cady—
GENERAL CHEMISTRY

By **Hamilton P. Cady**, Professor of Chemistry in the University of Kansas. Second Edition, 522 pages, 6 x 9, illustrated. **$3.25.**

A new and thorough revision of this standard college textbook for classes with limited time to devote to this subject.

In the present edition special effort has been made to clarify all obscure points and to make the definitions and laws stand out in relief by the use of different type.

Fawcett and Lee—
CITRUS DISEASES AND THEIR CONTROL

By **Howard S. Fawcett**, Professor of Plant Pathology, Graduate School of Tropical Agriculture and Citrus Experiment Station, University of California, with sections on oriental citrus diseases by **H. Atherton Lee**, Plant Pathologist, Experiment Station, Hawaiian Sugar Association; formerly Plant Pathologist, Philippine Bureau of Science. *McGraw-Hill Publications in the Agricultural and Botanical Science* 582 pages, 6 x 9, 205 illustrations, including 15 colored plates. **$5.00.**

A thorough, authoritative discussion of the present information on citrus diseases occurring in all parts of the world. The book will serve as a guide to growers

—in the identification of diseases;
—in the diagnosis of their causes;
—in the application of control measures.

Send for an approval copy

Upon request we shall be pleased to send to you any of our books on approval. There is no obligation to purchase attached—no agents—no red tape. The coupon to the right is for your convenience and ours.

McGraw-Hill Book Company, Inc.,
Penn Terminal Building,
370 Seventh Avenue,
New York

Millard—
PHYSICAL CHEMISTRY FOR COLLEGES

By **E. B. Millard**, Associate Professor of Physical Chemistry, Massachusetts Institute of Technology. *International Chemical Series.* Second edition. 458 pages, 5½ x 8, 81 illustrations. **$3.50.**

A textbook on the more important aspects of physical chemistry, together with accurate modern data which illustrate the applicability of its laws to the phenomena observed in the laboratory.

Lewis and Radasch—
INDUSTRIAL STOICHIOMETRY

By **Warren K. Lewis**, Head, Department of Chemical Engineering, Massachusetts Institute of Technology, and **Arthur H. Radasch**, Professor of Ceramic Engineering, New York State School of Ceramics at Alfred University. *Chemical Engineering Series.* 175 pages, 6 x 9. **$2.50.**

An aid in the technique of computation for all those interested in the chemical phases of industry. The book is intended as a tool for the chemical engineer, whether he is interested in present performance or design of equipment.

Weaver—
ROOT DEVELOPMENT OF FIELD CROPS

By **John E. Weaver**, Professor of Plant Ecology, University of Nebraska. *McGraw-Hill Publications in the Agricultural and Botanical Sciences.* 290 pages, 6 x 9, 115 illustrations. **$3.00.**

This is the first book to bring together the results of root investigations on crop plants.

McGraw-Hill
On-Approval Coupon

McGraw-Hill Book Co., Inc.,
370 Seventh Avenue, N. Y.

Send me the books checked, on approval:

....**Fath—Elements of Astronomy, $3.00.**
....**Shull—Heredity, $3.00.**
....**Cady—General Chemistry, $3.25.**
....**Fawcett and Lee—Citrus Diseases, $5.00.**
....**Millard—Physical Chemistry, $3.50.**
....**Lewis and Radasch—Industrial Stoichiometry, $2.50.**
....**Weaver—Root Development of Field Crops, $3.00.**

I agree to return the books, postpaid, after examination or to remit for them then.

Name .....

Address .....

Official Position .....

Sci. M. 10-1-26

A NEW METHOD
of Recording Frequency

Bulletin No. M-985, issue of 1926, describes the new L & N Frequency Recorder, of which advance announcement was made in the 1925 N. E. L. A. Meter Committee report. Extremely sensitive, it records on a very open scale.

It is highly accurate and permanent in calibration.

It has a negligible temperature coefficient.

Write for Bulletin M-985

LEEDS & NORTHRUP COMPANY
4901 STENTON AVENUE, PHILADELPHIA

LEEDS & NORTHRUP

Galvanometers
Potentiometers
Bridges and Resistances
Condensers and Inductances
Testing Sets
Recording and Controlling Pyrometers
Hump and Homo Electric Heat Treating Furnaces
Instruments for Measuring and Controlling Conductivity of Electrolytes and Hydrogen Ion Concentrations

THE SCIENTIFIC MONTHLY

OCTOBER, 1926

CUICUILCO AND THE ARCHAIC CULTURE OF MEXICO

By BYRON CUMMINGS
TUCSON, ARIZONA

In April, 1922, the writer, in company with Dr. Manuel Gamio, then director of anthropology in the Mexican government, visited a hill near San Fernando in the Federal District of Mexico which is surrounded by a lava flow known as the "Pedregal." There were some slight indications that the hill was not natural but was a ruin so old that time had obliterated all trace of its existence except this pile of rock covered with trees and overgrown with grass and brush. But here was a mound up whose sides had crept waves of black flinty lava that held the hill in a vice-like grip and sealed everything beneath from curious eyes. If it should prove to conceal a ruin, we had something here that might throw much light on the archaic culture of the Valley of Mexico. The venture appealed to the writer, and Dr. Gamio gladly assented to the request for permission to excavate there. The Mexican government furnished some men and the work started. Nine months were spent there through cooperation between the Mexican government and the University of Arizona. In July, 1924, the work

CUICUILCO BEFORE EXCAVATION.

BLASTING AND REMOVING LAVA FROM THE NORTHEASTERN SLOPE.

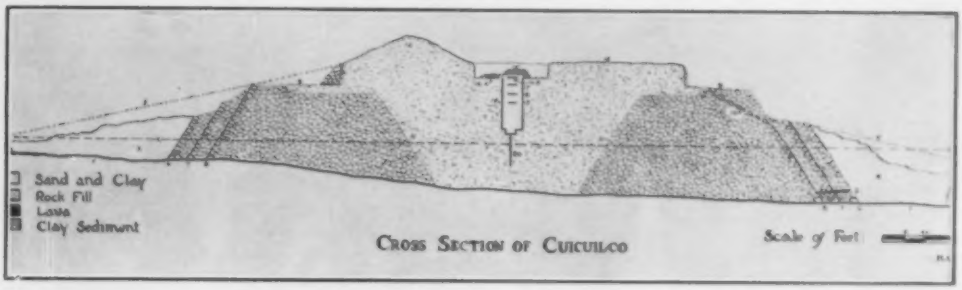
UNCOVERING THE SOUTHEASTERN SLOPE.

was resumed under the auspices of the National Geographic Society, the Mexican government and the University of Arizona and continued until September, 1925.

The mound proved to be an old temple built in the form of a truncated cone, with a diameter at the base of 387 feet, and at the platform of 291 feet, and a height of 74 feet. A cone of rock erected on this platform raised the total height to approximately 90 feet. The base lies buried beneath from 25 to 33 feet of clay, rock and lava, and the original top platform is covered with 18 feet of accumulated sand and clay and of clay and rock of later construction.

It was built like a great circular rampart of loose rock, with a central filling of clay and sand. This stone rampart is 70 feet wide on top and covers almost the entire area on the bottom. It is built of irregular chunks of lava thrown together and the holes filled with smaller pieces. The outer surface wall consists of large chunks of lava fitted together with some care at an incline of an average of forty-five degrees. The inner ends are bedded in smaller pieces of lava and the wall thus rendered quite compact and solid; but none of the stone has been surfaced in any way and there is no mortar or filling material of any kind, except the small stone. In the rock

THE OLDEST EASTERN ENTRANCE.



PROBABLE CONSTRUCTION.

UNCOVERING THE TOP OF THE TEMPLE. SHOWING CROMLECS SURROUNDING

portion of the top platform, the cracks and holes were filled with small stone and then the whole covered with a layer of clay that had been packed down by the tread of many feet.

Extending away from the structure two degrees north of east was an inclined causeway 86 feet wide. The rock fill behind the northern wall is 28 feet wide and behind the southern wall 16 feet with a central filling of clay 42 feet wide. This ascending causeway led from the surrounding plain to the bottom of a low incline made of huge boulders that led to the original platform. This boulder incline has a width of 33 feet and a height of 27½ feet, and this is the only approach to a stairway found in the entire structure. It requires very little imagination for one to see a gaily decorated procession of ancient tribal priests slowly mounting that long incline and stepping from boulder to boulder up that last ascent to the great dancing place on top. Here they formed and faced the east to catch the first rays of the Sun Father, as he sent his rejuvenating light and heat upon the haunts of men. Can you not hear their glad acclaims as they move in joyous harmony to their tum, tum! tum, tum! and chant their prayer of welcoming thanksgiving to their All-Father?

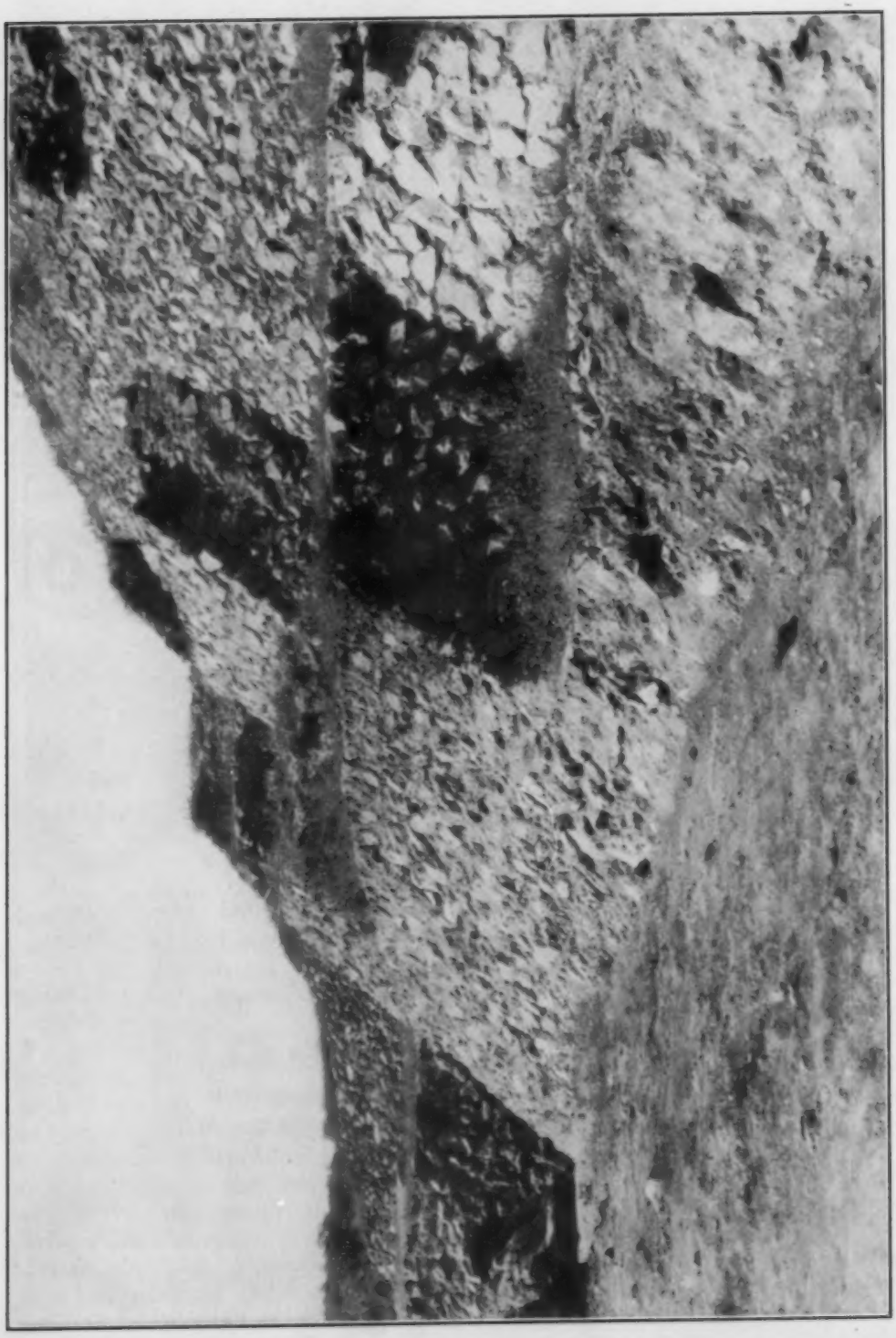
From the western side extended slightly to the south of direct west another inclined plane leading from the

TUNNEL BENEATH THE LAVA ON THE EASTERN SIDE. THE TIMBERS ARE 16 FEET HIGH.

THE EASTERN SLOPE BELOW THE LAVA.

top platform out some 150 feet from the base of the temple. This grand approach was 45 feet wide. The sustaining wall with its rock fill behind it on the south side was 8 feet and on the north side 6½ feet, leaving a clay fill of 30½ feet. On the north side of both the eastern and western approaches the causeways have been widened by the addition on the western side by three walls, respectively 12, 14 and 6 feet in thickness, and on the eastern side by two walls each 6½ feet thick. It would seem that the great force of inundations and floods had swept in from the northern side and necessitated the reenforcing of these projecting northern walls to prevent the undermining of their bases and the sweeping away of the great approaches.

After the original temple had been used for some time, a later chief desiring to make a better impression upon the gods and demonstrate to his people the superior power and favor he was receiving direct from heaven, enlarged the earlier structure by building a wall 10 feet thick at the base and 6 feet thick at the top outside the original surface. The top of the first wall had been injured somewhat and fallen into ruin as evidenced by the repair work that had been done along the upper edge of the first structure. These walls were carried a

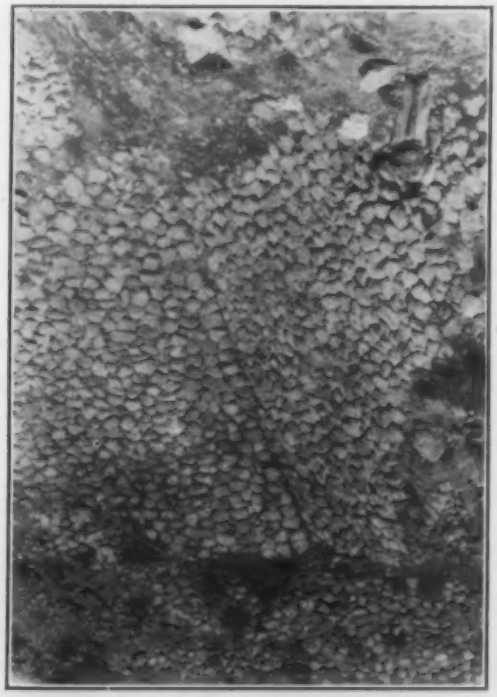


FROM THE SOUTHWEST.

little higher also and the platform correspondingly raised by filling the central section with earth. At the center of the original platform was a raised altar made of hard packed clay that had been painted a deep red. When the temple was enlarged and the platform raised, another altar was made directly above the first and painted red in a similar manner.

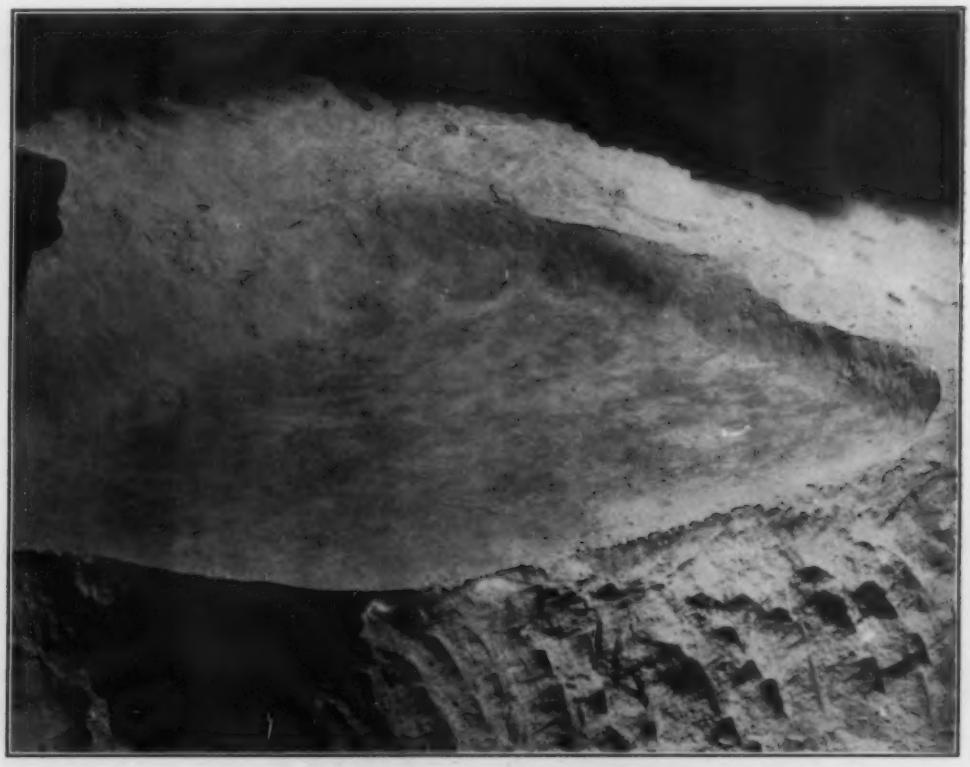
Some later big high priest and chief, not to be outdone by his predecessors, enlarged the temple again by another outside wall averaging about the same thickness as the first enlargement, namely: 10 feet at the base and 6 feet at the top. The platform was again raised and a new altar built. Thus generation succeeded generation and century followed century and still the old temple reared its great dancing place above the surrounding plain, the tribes still gathered there to try and ward off the evil and win the favor of the spirits that bring life and health and peace. All was color, joy and abundance. The Earth Mother responded to their petitions and their industry and smiled upon them with her bounty. But one day the Fire God became restless and the mountains round about gleamed with livid red and the Wind Spirit wafted thick clouds over the sacred temple of the Sun, and Cuicuilco became covered with layer upon layer of pumice, sand and ashes. Dense rains followed that washed this light material down her slopes and packed it around her base. In places the water cut for itself channels along the surface of the walls and washed fine

THE EASTERN SLOPE OF THE TEMPLE, SHOWING CROMLICS SURROUNDING BASE.



SECTION OF THE SURFACE WALLS WHERE EASTERN ENTRANCE JOINED THE MAIN TEMPLE.

THREE TYPES OF SURFACE WALLS ON THE EASTERN SIDE.



CLAY ALTAR BENEATH HORSESHOE ROCK ALTAR.

A HORSE-SHOE-SHAPED ALTAR LYING BENEATH THE DIRT COVERING OF THE TOP OF CUICUILCO.

sediment into the interior of the structure. That the structure must have been flooded for a time is evidenced by the fact that it is filled with fine water-washed sediment to an average depth of 6 feet.

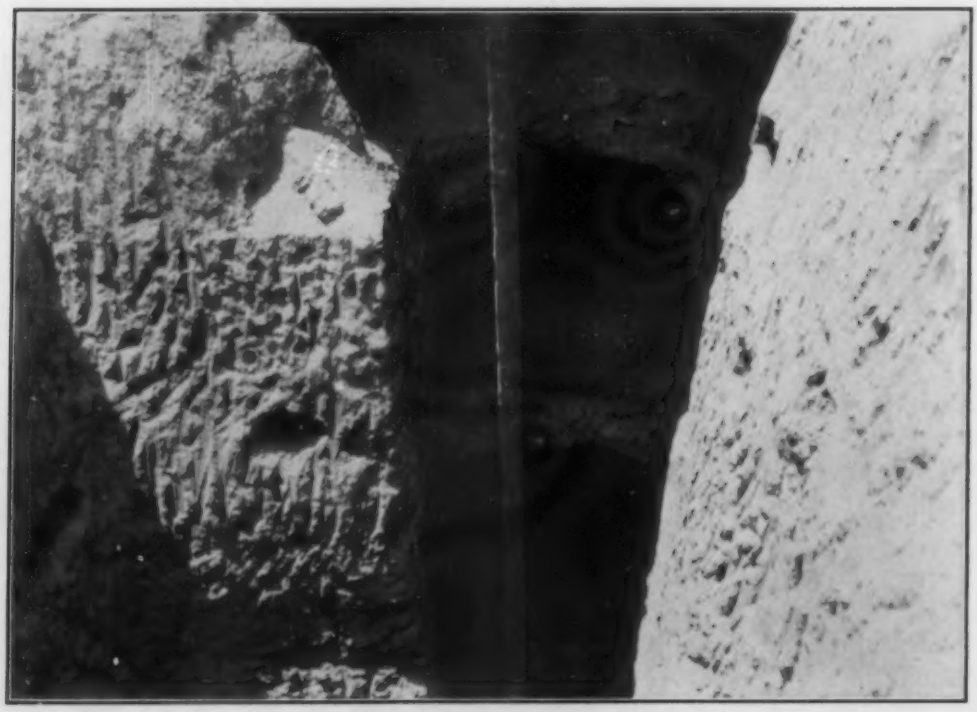
At some time during this period the waters subsided, the people were able to return to the locality, repair their temple and reestablish the worship of the gods. They did not undertake to clear away the volcanic material that covered the top but built a sustaining wall around the slope about 30 feet from the edge of the old platform and filled in the space behind, levelling it off for a dancing place in their ceremonials. In the center was raised another altar directly above those of their ancestors. Three other platforms were uncovered at different levels above this last one, showing that the surface was filled in from time to time and the sustaining wall carried higher and higher as the filling material demanded. There must have been a succession of volcanic eruptions that buried the altars and covered the surrounding platform. The first four of these altars were of clay painted red while the fifth was of water-worn boulders 22 feet long and 9 feet wide. The eastern half was 3½ feet high and shaped like a horseshoe. This altar rested upon a circular platform 68 feet in diameter made of large chunks of lava bedded in clay and sand. Four feet above this rock altar can be traced a clay floor upon which rests a foot of fine pumice covered with a thin stratum of black volcanic ash that must represent the surface level at the time of the eruption of Xitli and the flow of the "Pedregal" lava. Overlying this are eighteen inches of surface loam.

On this last and highest floor level there is no central altar, but slightly to

the southwest of the center rose a cone of lava rock and earth about 15 feet high. This must have been crowned by some sort of a wooden structure as old postholes were encountered in which had once stood quite large round timbers. This cone, with its wooden superstructure, must have taken the place of the central altar and must have been the center of the ceremonials celebrated on this spot by the last people who used the ancient temple.

These six platforms and their surrounding pavements superimposed at different levels through a depth of 18 feet demonstrate the long period of time through which men and women were accustomed to gather in this spot to appease the wrath of the gods and win their cooperation. And in the entire structure, even in the cone of rock surrounding the last pavement, no lava of the Pedregal period appears. The builders of this temple through its various stages of enlargement and repair all lived, built, worshipped and passed away before Xitli sent out its baptism of fire, followed by the great flood of seething, blistering lava that crept down the mountain slopes and out over the plain, burning everything to a crisp in its wake and surrounding the ancient temple of Cuicuilco, driving its worshippers before its scorching breath to seek safety in some part of the valley not cursed by the Fire God.

Above the base had accumulated from 15 to 19 feet of clay, sand and rocks before the lava flow occurred. This material was quite well stratified, consisting at the base of a layer of varying depths of fine sand and clay packed so hard that it could be removed only with a good sharp pick and plenty of muscle. Above this lay a stratum of rock that had tumbled down from the walls above with which was mingled soil containing organic material. In this stratum were



THREE CLAY ALTARS BELOW ROCK ALTAR ON TOP OF THE TEMPLE.

found broken pottery, clay figurines and crude stone inplements. Above this is spread from 3 to 4 feet of fine yellow pumice, clay and sand similar to the covering found on top. In this are found no human artifacts. An occasional chip of obsidian is the only thing that indicates the possible presence of man; but these even could be flakes broken off by nature. Overlying this is another stratum of rock and organic soil, which contains human artifacts in the shape of pottery, clay figurines and stone implements. These in time were covered with a stratum of yellow clay and sand 2 to 4 feet thick, of quite even consistency. Resting upon this is a layer of organic soil and rock that plainly was a surface level occupied by man for a long time. This is covered with a few inches of black volcanic sand, ashes and carbonized material, over which spreads the lava of the Pedregal. The lava sheet that crept in around the structure is from 5 to 20 feet in thickness and plainly poured over the plain in three successive flows. But fortunately the temple was so completely covered with earth and rock that the lava nowhere came in contact with the walls of the structure. About Cuicuilco above the edge of the lava and the carbonized stratum of that period lie on an average 2½ feet of surface soil in which are found some fragments of Toltec and Aztec pottery, and numerous obsidian blades struck from a core in long curving flakes.

Human remains were encountered in all these four levels, but all badly decayed and badly crushed. A few have been sufficiently preserved to judge their general physical characteristics. Their crania are dolicocephalic, of natural development with a strong underjaw, rather marked prognathism, strong supraorbital ridges, a low receding forehead and a high medial crest. They are quite similar to the crania of the cave people and the earliest pueblo people of Arizona.

The pottery of the lowest stratum is monochrome, either in natural reddish brown color of the clay or painted a brilliant red. All are well polished and well

POTTERY FROM BENEATH THE LAVA ON THE SLOPE OF CUICUILCO. JUST BELOW LAVA.

POTTERY FROM CUICUILCO. JUST BELOW THE LAVA.

IDOLS FROM CUICUILCO. CLAY FIGURINES WITH RECEPTACLES FOR INCENSE. FOUND AT EDGE OF LAVA.

FIGURINE TYPE FOUND NEAR BASE OF TEMPLE, 15 TO 19 FEET BELOW.

FIGURINE TYPE FOUND JUST BELOW THE LAVA.

FIGURINE TYPES FOUND 6 TO 8 FEET BELOW THE LAVA.

shaped. The figurines are small, stiff and erect in position, with a receding forehead and a high crested head. The prominent nose and the receding forehead suggest the Mayan type of later date. The hair is represented as long and arranged in various elaborate braids and rolls and falls over the shoulders and down the back.

In the second stratum at an average of about 6 feet above the base similar pottery is encountered but of more varied form and a little attempt at decoration is seen in the grooved necks of some ollas. The brilliant red has nearly disappeared and there is a greater preponderance of reddish yellow and dark brown. The figures are much better shaped and finished. The features are much better formed but are still conventional and the headdress consists of numerous fillets intertwined with the hair. A considerable variety of position is found and the seated figures with crossed legs were introduced.

The stratum occupying the first two feet below the lava contains many human artifacts and remains. The population occupying the surrounding plain must have been numerous, but their culture was crude. The pottery was mostly thick black and reddish brown in cazuelas, shallow bowls and cups. The surface is fairly well smoothed but is irregular and unpolished. Some crude pieces have a decoration consisting of a band or rope of clay overlaid upon the surface and arranged in a wave line or indented with the thumb. The figurines are flat and squatty with crudely molded features and a turban-like headdress. The eyes and mouth are made by sticking strips of clay on the face, and the former are often set obliquely. Some of the figures

have the seated pose similar to the characteristic pose of Buddha. This culture could not have been an outgrowth from either of those already mentioned as the earliest. It was the attainment of a cruder people who after the second great covering of Cuicuilco came into the region and took possession of the land. They very likely were a more barbaric people from some remote section of the wooded mountains who moved down into the plain after the earth became quiet and sought to maintain themselves in the more fertile plains.

Thus three quite distinct periods of archaic culture are manifest beneath the lava of the Pedregal in the the Valley of Mexico. The first and the second periods show superior workmanship in pottery and figurines to that encountered in the third or latest. The first and earliest presents characteristics in pottery and figurines different from any artifacts hitherto encountered in the remains of the archaic age uncovered at San Angel and other places in Mexico.

If the lava flow occurred at least two thousand years ago as attested by three most eminent geologists, Tempest Anderson, of England, Karl Vittich, of Germany, and N. M. Darton, of the U. S. Geological Survey, then the geological and cultural stratification of the deposits lying between the base of Cuicuilco and the lava indicate the lapse of a much longer period of time between the building of the temple, Cuicuilco, and the eruption of Xitli and the formation of the Pedregal. Eight thousand years is a very conservative estimate of the time that has elapsed since the primitive people toiled up the slopes of Cuicuilco and reared a mighty temple to their gods.

RESTING BENEATH 20 FEET OF LAVA AND DEBRIS.

THE DUTY OF ASKING QUESTIONS AND THE PRIVILEGE OF DRAWING PICTURES

By Professor H. F. MOORE
UNIVERSITY OF ILLINOIS

WISHING to follow the best American traditions, the writer will begin this paper by telling a story. Following the most dignified traditions, the story is an old story. The writer thinks that it is a good story.

The small boy with the cherub face gazes up into his mother's eyes. "Mother," he says, "what does God look like?" "Hush, dear, you must not ask such irreverent questions." Follows a silence so prolonged that mother becomes anxious—a glance shows that the cherub is busy with pencil and paper. "What are you doing, dear?" "Drawing a picture of God." "But, dear child, no one knows what God looks like." "They will when I finish this picture."

Let us consider the above story from the viewpoint of the research worker in science, let us consider it under three headings: (1) The tendency of the small boy to ask questions, difficult questions, questions unsettling to many fond preconceptions; (2) the reaction of the mother towards such questions, a reaction in which every one of us has taken part many times—sometimes at the sending end, and sometimes at the receiving end; (3) the tendency of the small boy to create a concept which shall answer his own question—an attempt made with very inadequate preparation and with poorly developed technique.

Taking up the first division of our subject, the writer wishes to advance the thesis that in asking what God looked like the small boy was following a course of action which is eminently praiseworthy, always for investigators in "pure" science, nearly always for workers in "applied" science, and frequently for literary men, musicians and painters. It is, the writer holds, the bounden duty of the searcher to search, and to search with especial diligence in the places where he is vigorously assured that the object of search can not be found or where former search has been in vain.

For any one engaged in any kind of scientific research the constant attitude of questioning is so much a matter of course that it seems almost as strange to speak of the *duty* of asking questions as it would be to speak of the *duty* of eating. But to the devout soul who finds worship easier and more satisfactory than investigation the *duty of asking questions* is by no means clear. When we speak of there being no conflict between science and religion we must bear in mind that when considering his professional field of work, and during office hours, the effective research worker shows only the minutest traces of childlike faith in any revelation or authority. He questions the statements which the text-books call laws. He is not afraid to ask, "Are Newton's laws of motion really true, or must we regard them as good working approximations for terrestrial mechanics?" He squarely faces the query, "Is there a qualitative difference between the intellectual life of man and the intellectual life of other beings having animal life, or is the difference merely quantitative?" He does not shrink from or sidestep the question, "Is there any evidence of observable phenomena tending to prove the existence of individual life after physical

death, or must we seek such evidence entirely outside the world of physics and chemistry?" Before any jury of scientific workers our small boy is justified in asking what God looks like.

Now let us consider the viewpoint of the mother who objected to the small boy's question as irreverent. She belongs to a very large group whom the workers in scientific research are apt to forget or actually to disparage—the people who do not approach the events of each day with a questioning attitude, the people for whom most fundamental ideas are fixed—inert, safe, reliable, comfortable, lovable people. With this group in their dislike of the animated question mark are some literary people who write interesting accounts of the way in which they imagine scientists think and work. Still another group of objectors to the small boy and his like are the people who have stocks of current commodities which they wish to sell—people who have coal stoves to sell and who do not wish the question of the relative effectiveness of coal stoves and oil heaters even to be raised, people who have nicely finished religions to sell—or to impose—and who are moved to deep righteous wrath if the question is asked whether there may not conceivably be other religions better than theirs—yes, scientists who say, "Now we have absolutely proved that . . ." and who brand as an impertinent fool any questioner who mildly asks for quantitative limitations to be placed on the "absolutely."

The objection to the folks who ask questions, who have their typewriters equipped with a question mark on both shifts and a period on only one shift, is first of all that they have a very trying habit of questioning a lot of statements and beliefs which everybody knows to be true, and every once in a while they get an inconveniently large number of people to see that the certainties in question are not true at all, and "about that time look out for storms"—sociological "twisters" such as have swept over Münster, Paris and Moscow. Then in the second place the questioners ask their questions at such awkward times. With the second objection the writer must confess a good deal of sympathy, and he believes that while the question should always be freely admitted to the mind of the searcher often the question may be kept there—for a while at any rate. As an engineer the writer holds that before bothering other folks with a question its importance should be weighed, and some estimate made of the time and energy which will be diverted from other important things to the answering of the question.

Perhaps there is not a better illustration of the question inopportune than the question always raised whenever the Book of Jonah is under consideration. The Book of Jonah is one of the noteworthy attempts to answer the little boy's question and to draw a picture showing what God looks like—a picture of a powerful kindly being whose loving kingdom reached even from Tarshish to Nineveh, and who would have mercy on a city where dwelt "more than six score thousand persons that can not discern between their right hand and their left hand; and also much cattle." And before folks get to thinking of that picture some one asks an honest but unimportant question, "But did the great fish really swallow Jonah?" The writer declines emphatically to notice the question other than to remark that it is a pity that by so many folks the unimportant fish has been allowed to swallow the concept of God given in the book of the Prophet Jonah and to recommend to those who really feel that the fish question must be answered to look at the picture of God a while before they ask aloud about the fish. Yet, after all, while the writer decries the thoughtless blurting out of the questions regardless

of time and place, he does maintain that the searcher after truth must always be a questioner; he claims that Thomas was no less worthy a disciple than Nathaniel.

The laws of the Medes and Persians did not endure forever, and to the research worker all our scientific "laws," our civil and criminal codes, our creeds, yes, even our traditions and customs, must be regarded as open to amendment and sometimes to repeal. And if the writer were called before a jury of evangelists, salesmen, soldiers and lawyers to defend such heresy he would answer as an engineer and say that in all human experience there is no more evident phenomenon than that of change. Again and again must the modern journeyer say, "We have not passed this way before." So far as we can see yet there is imposed upon us the necessity of constant adjustment to a changing world. The only choice we have lies between an attempt to make suitable adjustments and a mournful willingness to lie down and shortly to die. There is no point in the known universe of which we may say, "Here we are at rest." There is no custom or tradition of man or of beast of which we may say, "This, was, is and shall be." There is no law either of physical science or of the courts of which we may say, "This is an inerrant and complete expression of truth."

If we are to adjust ourselves to change in any effective way we must approach events with a questioning attitude; otherwise we are gamblers taking the right-hand or the left-hand turn by the toss of a coin rather than by asking the dwellers along the road. Or, perchance, we may be of those who wait for "voices" to guide them. Let us not deny that there are "voices," but let us not forget that there are very many noises which sound like "voices" but are not, and that "voices" alone are not very adequate or reliable guides. We must ask questions; we can not assume that the traveled way is the right way or that last year's road map is certainly good for this year.

Yes, in his questioning I defend our small boy. He asked his question quietly and when no other matters of greater importance were being discussed, and I can not agree with his mother's desire to make him forget his question. But how about his next step, his very natural attempt to answer his own question by drawing a picture of God? Here, too, we must admit that he followed a much travelled path of scientific research. For what are all our hypotheses and theories and laws but pictures? May I quote the outstanding nineteenth century philosopher of mechanics, Ernst Mach.

> Thence is imposed the task of everywhere seeking out in the natural phenomena those elements that are the same, and that amid all multiplicity are ever present. . . . When once a person has acquired the skill of recognizing these permanent elements throughout the greatest range and variety of phenomena, of seeing them in the same, this ability leads to a *comprehensive, compact, consistent,* and *facile conception of the facts.* When once we have reached the point where we are everywhere able to detect the *same* few simple elements, combining in the ordinary manner, then they (phenomena) appear to us as things that are familiar . . . they no longer perplex us, they are explained.

We explain unfamiliar things by drawing pictures of familiar things which resemble the unfamiliar.

Now no picture is a complete representation of the thing pictured. For one thing a picture is the representation of what is seen from one viewpoint. A picture of Hannibal, Missouri, from the top of the tall cliff overlooking the town is very different from a picture from the railway station, and that picture, in turn, is very different from a picture taken looking down the street where Mark Twain lived; yet all three are pictures of Hannibal.

So the elastician draws a picture of the behavior of metals from the viewpoint of their minute changes of form under pushes, pulls, bending or twisting; the engineer draws a picture of the behavior of metals from the viewpoint of their resistance to being pulled in two, or crushed, or sheared off, and the metallurgist draws a picture from the viewpoint of the crystalline architecture of the metal, and the pictures are decidedly different. Yet each is a serviceable picture of some phase of the behavior of metals; none of the three pictures is a *complete* picture of the behavior of the metals, and none of them can be characterized as "untrue."

Will the reader step aside from the path a moment and in imagination take a view of four pictures of "patriotism" painted, respectively, by General Pershing, Jane Addams, Herbert Hoover and Calvin Coolidge?

To persons who have been accustomed to getting ideas of what scientists think from popular writings about sciertists and scientific work the thesis that scientific theories are merely pictures must sound like nonsense. Do we not hear how Dr. Jones has "absolutely proved" the correctness of this theory and that Professor Brown has "completely demolished" that hypothesis? Are we not assured again and again that science rests on a basis of *proved* fact, proved by experiment? In the recent anthropoid carnival at Dayton, Tennessee, were we not told that unless he had a basis of *proved fact* the scientist must not cry aloud nor let his voice be heard in the streets, but must leave the classroom and the lecture platform to the less fettered preacher and lawyer.

As representative of the views of scientists themselves the writer wishes to present a translation of a paragraph in a little book, "L'Unité de la Science," by M. Leclerc du Sablon. The paragraph occurs in a chapter on the principle of causality, in which the author, who is professor of botany in the University of Toulouse, is discussing the basis for the principle which is fundamental to all other scientific theories and laws—the principle which states that there *are* causes and effects.

> The principle of causality, like other principles, is a concept of our mind, suggested by experience, but going beyond the data of experience. We conceive that the same causes bring about the same effects, although we have never seen two phenomena exactly alike. We believe in determinism in the realm of physical and biological phenomena, although there has been given only an approximate verification of that proposition for a limited number of cases. When we observe a happening whose cause escapes our observation we *prefer* to acknowledge our ignorance and our inability to discover the cause rather than to admit that there may be effects without causes and phenomena entirely independent of laws.

The assumption of cause and effect fits in well with nearly all the happenings we observe from day to day—at least with the happenings in the world of material things; the assumption enables us to think, and rather than passing time idly watching the clock of life we "prefer" an occasional attempt to "see the wheels go round."

Now if the very existence of cause and effect is an assumption which we accept because we "prefer" it to other assumptions, is it not reasonable enough to regard all postulates, hypotheses, theories and laws not as statements based on "proved fact" but as pictures which represent clearly and fairly accurately the happenings which experienced observers have witnessed? When a new picture is presented for our inspection we ask not is it "true" or "false" but "Is the new picture a better picture than the old pictures of the same thing?" "Is it more beautiful?" "Is it more accurate in its draftsmanship?" We do not expect the old pictures to be torn down at once from the walls of the scien-

tific picture galleries, but rather that for a while both the new and the old pictures shall hang on the walls until the scientist has decided which picture he prefers.

For something like two and a quarter centuries every student of mechanics had one and only one picture hung on the walls of his mental workshop; the picture of masses and accelerations painted by Isaac Newton in the "Principia." Then came questioners—Michelson and Morley and others, who began to ask if Newton's picture really did represent masses and accelerations or whether it was a vivid but inaccurate cartoon. Then came Einstein with another picture for the student of dynamics to hang on his workshop walls. But the Newton picture is not torn down. In fact, for engineers and most earthly mortals it is still the picture we look at. The masses and accelerations we have to work with do fit with the Newton picture very well indeed. The student of atomic behavior and the astronomer may have to hang the new picture on their walls, but the writer ventures to predict that it will be a long time before the Newtonian picture is torn down.

But before it is hastily concluded that we are to approve the attempt of our small boy to draw a picture of God let us consider one danger which is always present for the drawer of pictures. Folks do not worship *questions;* they are very apt to worship *pictures.* The giver of the ten commandments clearly recognized this danger and sternly forbade attempts to make pictures of God on the ground that one is very likely to fall down and worship the picture he has made.

Idolatry is by no means absent from the world of science. One of the commonest forms of scientific idolatry is formula worship. A scientist, either a pure scientist or an applied scientist, starts to develop a hypothesis. He finds it convenient to borrow a set of tools from his cousin the mathematician. Now there is no more fascinating employment than playing with mathematical tools—note I say playing with mathematical tools, which does not necessarily imply becoming a mathematician; and the beautiful regularity of the picture carved out by the mathematical tools makes the scientist forget what he was drawing a picture of and declare not that he has drawn a picture, but that he is telling the whole truth and nothing but the truth about his subject of research. Take, for example, the theory of elasticity, a beautiful picture, a most useful picture, a picture drawn by artists of marvelous technical skill. It does not tell the whole truth about the elasticity of actual materials because actual materials do not have the perfect homogeneity and the indefinite divisibility which are assumed for materials in the picture. For most cases the picture may be regarded as of sufficient accuracy for use, but it is not by any means inerrant, nor is it the complete expression of the truth about the elastic behavior of materials. Yet many an engineer worships unquestioningly the theory of elasticity.

The writer has chosen as an example of scientific idolatry terrestrial mechanics, a science which has been singularly free from passion and emotion in its development (in sharp contrast to celestial mechanics). If we consider the history of astronomy or biology we shall find that in those fields picture worship has roused storms of passion. How easy it is for a biologist to become a propagandist for the theory of evolution—as he interprets that theory—and how very easy indeed is it for an emotional Bible worshipper to become a propagandist against evolution—as he sees it. The marvel is that the great bulk of biologists and preachers have not become seriously entangled in the current tournament of slogans and mud slinging about evolution.

The writer's objection to idolatry are two in number: first idolatry leads to propaganda and undignified quarrels. The spirit of search and questioning makes a man humble, the spirit of idolatry makes a man cocksure and filled with a desire to impose his sureness on his neighbor. The writer does not like either propaganda or undignified quarrels—there is a fascination in a fight, but it is a devilish fascination. The second objection to scientific idolatry is more serious. Scientific idolatry shuts off questions and discourages or forbids the drawing of new pictures.

In view of the ease with which folks come to worship pictures, especially pictures which they themselves have drawn, the writer is not at all sure that our little boy was justified in trying to draw a picture of God. The drawing of pictures is not a duty, nor even an inherent right, but a privilege to be won. There is no intention of offering suggestions for the organization of a license board from which would-be scientific theorists might receive leave to carry on their trade. However, before a scientist should essay to draw pictures of his science—or at least before he essays to exhibit such pictures—he should have some training in draftsmanship, and he certainly should have training in observation so that he can distinguish the high lights and the deep shadows in the thing he is trying to draw. There is no more effective way of drawing a false picture or of making a misleading hypothesis than the insistence on equal emphasis for important and unimportant details. Frequently a flat characterless photograph is far less true as a picture than a sketchy cartoon.

On the ground of ability to evaluate emphasis and on the ground of drafting ability I fear we must withhold approval of the attempt of our small boy to draw a picture of God.

Now the writer wishes to maintain that the would-be drawer of scientific pictures should have the ability and the willingness to look at his world from more than one viewpoint. He recommends to all such the rereading of Saxe's satirical ditty on the six blind men of Hindustan who went to see the elephant, and who as the result of their several observations were firmly convinced that the elephant was like (1) a wall, (2) a snake, (3) a fan, (4) a rope, (5) a tree and (6) a spear; and how "these men of Hindustan disputed loud and long . . . though each was partly in the right and all were in the wrong." The painter of pictures will finally choose one viewpoint for his picture, but he does so only after he has recognized that there *are* other viewpoints and he looked at things from them. Moreover, he does not think of his selected viewpoint as "right" against the other "wrong" viewpoints. He thinks of it as better serving his purpose.

But let us listen to the objectors to the multi-viewpoint requirement. In that group we see the philosopher of mechanics, Ernst Mach, who already has spoken to us, and who speaks of

> That ideal of a *monistic* view of the world, which is alone compatible with the economy of a sound mind.

And he voices the feeling of many a trained scientific worker and of some disciples of idealism that the considering of many viewpoints leads to a hazy, lazy, vague mysticism and that the maker of scientific hypotheses should take only one viewpoint.

Is a monistic concept of the world possible at the present time? Can it be made a clear concept? Is it a desirable concept? On the first of these questions the writer would vote in the affirmative, but he would swing to the negative side on the second and third questions. In an attempt to justify his vote he asks you to look at two pictures hung on the

walls of the International Gallery of Hypotheses and Theories. One picture is labeled "determinism" and shows the world as a toy electric train running round a circular track in a Christmas toyshop window. The men and women in the train are little tin images, and acting in response to imposed accelerations they make certain determined movements. The motive power is entirely outside the picture, and the train goes round and round and round and round. The picture shows spectators (large tin images, says the painter) who seem to be talking vigorously, doubtless declaring that on the hundredth circuit the speed of the train is less than on the first and computing when the train will stop.

And this, says the painter of the determinism picture, is a picture of *us*. We are the little tin passengers, and we move and love and hate and eat and beget and joke only as imposed accelerations reach us, and then we act according to a fixed, imposed plan.

But the painter of the determinism picture has not given an altogether convincing picture. Our attention drifts toward the folks looking in through the toyshop window, and though our determinist painter says they are merely larger images, yet it seems a very evident fact that each one of them can *choose* whether to stand looking in at the window or to go home to supper and that probably some of them can choose to go into the store and buy the train. The painter himself has come up as we are looking at his picture and he says that choice is all illusion, and makes a rapid pencil sketch to show how really the apparent choice is an effect from a predetermined arrangement of atoms into foreordained patterns. There are millions of billions of atoms involved; he indicates these with some heavy shading. We can not say his picture is false, but it certainly is complicated and foggy, it arouses in some of our minds about the same degree of enthusiasm as did the famous futurist picture of the nude descending a stairway, in which it was very difficult to tell the nude from the stairway. We are not convinced and move over to view the other picture.

The second picture is labeled "Purposiveness," and the painter, a keen, confident man, immaculately dressed, stands beside it. This picture also purports to be a complete picture of the world. It shows a tall stern-faced man pointing with unshaking index finger towards a point due west where a very steep mountain towers into the air with a remarkably snaky path winding up its side along which a few pilgrims are toiling. There is a wild torrent which crosses the path at frequent intervals. It is a very "live" picture. One can almost hear the crisp slogans from the lips of the stern-faced man, "Go forth and conquer," "He who will, can." "Others have achieved, why not you?" and we begin to feel that here is the real monistic concept of the world until a humble individual with a slide rule asks for an estimate of the coefficient of friction between sole leather and the surface of the winding pathway, and about the nature of the bed of the raging torrent which must be crossed many times before reaching the summit. The painter replies in a ringing baritone voice, "The human will can overcome all obstacles," but the man with the slide rule shoves it in and out like a small trombone and shakes his head.

No, the second picture is not convincing, either. Any one could climb the hill for a greater or less distance, but there are loose stones on the paths, uncertain footing in the stream, and the possibility of nightfall ere the summit is reached. We know of no one who ever climbed quite to the top of his particular hill, and we turn away from this picture.

Chancing to step back a bit and taking one glance in the direction of the two

pictures we suddenly become aware that they go very well together. The high lights and deep shadows of the "purposiveness" picture make a pleasant contrast with the flat tones and clear-cut drawing of the "determinist" picture, and we spend the rest of our time in the picture gallery gazing at both pictures. To be sure, certain of the group round the "determinist" picture glance our way and make scornful remarks about "mystics," tapping the forehead significantly. Then some of the group round the "purposiveness" picture urge us to cease from halting between two opinions and ally ourselves with the strong, purposive folk ("red-blooded hemen," one enthusiast calls them). But still to us the middle viewpoint is best and pleasantest. We "prefer" it. I wonder whether to-morrow or next week yet another picture will hang in the gallery, and whether it will be a more nearly complete picture.

On the ground of ability to see what he is depicting from several viewpoints we can not justify our small boy in his attempt to draw a picture of God. Children are notoriously monistic in their view of the world, which they take at any given time, and if the boy's mother destroyed his half-drawn picture we can not blame her as we did for suppressing his question. Yet I like to picture the small boy say fifty years later. He is still drawing pictures, and now his mother no longer suppresses them. As he works away at his easel a friend enters the room and asks, "What are you drawing now?" and the grown-up boy, who has seen life from many viewpoints and who has learned the importance of high lights and shadows, answers "I am drawing a picture which I hope will make folks think about God."

RACE AND CULTURE

By Professor WILSON D. WALLIS
THE UNIVERSITY OF MINNESOTA

SOCIAL development is intimately related to biological species. The fowl of the air are almost the only architectural nest-builders. Not only so, each species of birds has special methods of nest-building which no other species duplicates. The dams constructed by beavers are peculiar to them. Some animals are by nature social, while others live an isolated and irresponsible life. Some are amenable to civilizing influences and can be domesticated, while others, such as the tiger, refuse to enter man's social circle, and reject the social contract. The timid are timid by nature, the ferocious are born ferocious and ferocious remain.

The qualities peculiar to the species are inherited. The nest-builder owes its abilities to its ancestors. The humming bird falls heir to one type of nest-building art, the swallow to another; beavers are indebted to beavers for the ability to construct the peculiar type of dam of which they are capable.

Mankind constitutes a species apart from the rest of the animal kingdom and has social attributes not shared by the other animals. But in addition to being a species apart from the rest of the animal kingdom, man exhibits within his species such marked differences in physical characteristics that varieties or races of mankind are recognized and by some are reckoned as of primary importance in social life.

SPECIFIC RACE TRAITS

The differences in mental and in social make-up exhibited by the various races are accepted as specific race traits, qualities innate in a given race, not shared or shared only partially by other races. Assertion of race superiority and race inferiority is equivalent to a declaration of limited possibilities of advance due to the factor of race. There are considerable differences between one race and another, differences as old as history, and the recognition of the existence of these differences is almost as old as historical documents. The Egyptian, the Persian, the Assyrian, each had specific qualities better known than admired by contemporaries. The Greeks believed they constituted a class far above the *barbaroi* of the non-Greek world. In his own eyes, the Roman, by virtue of birth, was superior to other peoples. The Latin considers his race superior to that of the Teuton, and both agree on their respective superiority over the Slav. Their case is the stronger because race differences not only exist but persist.

According to some writers, social development demands a certain kind of racial substratum. Thanks to this substratum the stream of race differences flows on, each within the confining banks imposed by race potentiality. The findings of ethnology have called attention to the fact that culture differences may be innate in race. Differences which exist and have existed for many centuries between Mongoloid, Caucasoid, and Negroid, suggest that in race there is something more than mere diverging streams of historical influences. The foundation for these innate race characteristics sometimes has been assigned to morphological differences, especially to differences indicating that in physical make-up the lower peoples are more closely akin to anthropoid apes than are Europeans. In the negro one finds the long head, long heel, long forearm. Size of brain in proportion to size of body is less in Negro than in European. These

characteristics, however, justify no inference as to social or mental qualities. Physical resemblance to anthropoid apes establishes nothing more than physical resemblance. One can not infer that the type nearest the apes in physical characteristics is also nearest them in social and in mental characteristics. The structure of the European male, for example, is nearer the type of ape than is that of the female, though a marked leaning toward the ape in mental life of males as contrasted with females would be ardently denied by many members of the stronger sex. The proportion of size of brain to size of body is much less in the adult than in the infant, yet most philosophers would deny that in this case intelligence decreases as body outruns brain. The applications of similar logic to problems of race is obvious.

Attempts have been made to discover race differences in innate psychic constitution. Some races are represented as having strong emotional tendencies, others as being naturally phlegmatic, with corresponding differences in culture achievement. The experimental psychologist has taken his laboratory to primitive peoples or has brought representatives of primitive peoples to his laboratory, in order to study physiological and elementary psychological reactions. In sense discriminations, acuteness of hearing, touch, sight, no differences were detected which might not be credited to differences in previous training, experience and the almost controlling factor of interest.

The natives of the Torres Straits, for example, discriminate objects in a dim light better than do Europeans; but they are accustomed to finding their way about in no other light than that of a campfire, a torch, or the stars and moon. The European, accustomed to artificial illumination, has little practice in a game at which the savage has much experience.

It is not clear, therefore, that the results of these psychological experiments reflect differences attributable to race. Possibly they show merely differences in education and in interest. If such be the case, the test is a test of culture rather than a test of race. Commenting on his psychological observations among the Urales and Sholagas of the Indian jungle, Dr. W. H. R. Rivers, who has made more psychological tests among savages than has any one else, says:

> These people were hardly ideal subjects for psychological experiments.
>
> They came to us in a state of abject fear at the prospect of our examination, and in some cases continued so terrified throughout that their observations were of little value. In most cases, however, they soon found that we were comparatively harmless, and settled down to their observations satisfactorily, to become again much alarmed when they thought over the meaning and probable consequences of the examination.

This state of alarm and of apprehension, of divided interest and attention, in varying degree is characteristic of all primitive peoples with whom the psychologist deals. These disturbing elements must greatly vary the results and in so far vitiate the value of the findings. Until the results of the experiments are weighted they possess little value as tests of the psychological capacities of primitive peoples.

The importance of "consciousness of the task" as a factor in determining performance has been well stated by a contemporary psychologist.

> There is, for example [says Bartlett], all that may be involved in the understanding of instructions given, in the subject's own conclusions with regard to the purpose of the experiment, and in the affective accompaniment of his responses. Beyond these intellectual and affective characters, however, consciousness of the task appears in all cases to involve what must be described as an active prompting, contributed by the subject himself, in the direction of this or that type of response. . . . Any one who has had any experience whatever in the setting and marking of mental tests will at once recognize how great a difference this active cooperation of the subject may make.[1]

[1] F. C. Bartlett, "Psychology and Primitive Culture," 270–1. New York, 1923.

In the experiments of Rivers above referred to the highest rating in the vision test was scored by a Sholaga serving under the Forestry Department as bungalow watcher. He discerned correctly the position of the letter E at a distance of eighteen meters. Rivers deemed him "distinctly superior to the rest in general intelligence, though it may only have been that he had had more intercourse with the outside world, and was, in consequence, less timid and reserved." May it not have been due in part also to his experience and training as a bungalow watcher, a vocation which gave him in the tests a fitness which the others could not claim?

Intelligence Tests

Much has been made of the fact that the intelligence tests conducted in the United States army camps during the World War show a rating of negroes at a distinctly lower level than that of the whites. We give below the rating of intelligence percentages of inferior, average and superior:

Camp		No. of Cases	Percentage Inferior	Percentage Average	Percentage Superior
	(W = White; N = Negro)				
Lewis	W	834	8.4	72.9	18.7
	N	118	23.6	66.9	9.4
Devens	W	8,247	20.1	69.2	16.7
	N	114	32.4	65.7	1.8
Upton	W	7,876	22.1	66.6	11.3
	N	326	44.1	53.7	2.1
Dodge	W	4,575	18.3	80.6	11.1
	N	831	50.5	47.3	2.2
Custer	W	4,933	20.6	66.9	12.5
	N	819	58.3	38.6	3.1
Travis	W	6,514	34.4	56.1	9.5
	N	1,375	70.2	29.2	0.6
Grant	W	7,671	18.2	69.6	12.2
	N	1,129	76.3	22.8	0.9
Taylor	W	7,363	22.6	62.9	14.5
	N	2,416	80.3	19.0	0.8
Wadsworth	W	8,243	27.0	61.2	11.8
	N	1,634	92.8	7.0	0.1
All Camps	W	93,973	24.1	63.9	12.1
	N	18,891	78.7	20.6	0.7

If we take the total for all camps we find the lower intelligence more than three times as frequent in negroes as in whites, the higher intelligence about one eleventh as frequent, and the average intelligence less than one third as frequent. These differences, in varying degree, hold for each camp as well as for the total of all camps, the negroes invariably showing a higher proportion of cases of inferior intelligence, fewer of average intelligence and markedly less of superior intelligence. The ratios differ for both whites and negroes from camp to camp and differ more in the case of negroes than in the case of whites. In the case of negroes the highest ratio of superior and the lowest of inferior occurs in Camp Lewis, a camp of the northwest, the next lowest ratio of inferior being found in Camp Devens, a camp of the northeast, while highest ratio of inferior rating and the lowest of superior is in one of the southern camps, Camp Wadsworth. The fluctuation from camp to camp in the rating of negroes suggests that the rating of the negro depends largely upon the state of origin. A tabulation of results according to state of origin of the negroes shows that the surmise is well founded. Among the states of nativity of negroes for which data are given for more than one hundred cases the greatest frequency of lowest rating occurs in South Carolina (77.7 per cent.), Alabama (67.6 per cent.), and Florida (68.2 per cent.); the highest percentage of average rating, known as "C," being found in Indiana (20 per cent.), Illinois (19 per cent.), and Kansas (21.4 per cent.). Geographical variations in rating are not peculiar to negroes but hold for whites as well, and "suggest that there probably are more or less marked differences in the levels of intelligence in different parts of the country"—a surmise which no one would challenge. In a word, the fluctuation in negro-rating suggests that the difference between negroes and

whites is to be credited to social heritage rather than to race.

The tests are standardized on the basis of Anglo-Saxon experience and education and show differences in social experience and tradition of which race is but a chance carrier. Devise tests which suit the intelligence, interest and training of the native Zulu and he will do better at them than will the average white. The relative standing depends considerably upon who devises the tests and upon the criteria imposed. Tests made, previously to the army tests, upon white and negro children show that the comparative rating of negro children varies with the social classes chosen for comparison. Attempts to select white and negro children of the same educational standing, as was done in tests made in the south, and in tests made in Philadelphia, where, at least in the latter case, the economic and home surroundings were taken into consideration, are in the right direction. But it is impossible to select groups of whites and groups of negroes of the same home environment. The traditions, aims, ambitions, hopes which pervade one group are different from those which pervade the other and are favorable to the whites. The comparison is fruitful only when we select those from the same environment, with the same training, experience and incentive.

Neither does the greater prevalence of feeblemindedness among negroes show that this is attributable to race. Is feeblemindedness more prevalent among the negroes in Africa than among those in the United States, or has this trait grown apace with contact with American civilization? When the psychologist answers that question we will have grounds for deductions about traits attributable to race. Not until then can we allege that the greater prevalence of feeblemindedness among the negroes of the United States is evidence of inferiority due to race.

As regards the interpretation of the mental tests applied to members of racial groups, it is assumed by some psychologists that the races should be rated according to the standing assigned individuals by the tests. This is putting the cart before the horse. The tests are justified or condemned according as they harmonize with otherwise demonstrated race intelligence. A test of the intelligence of individual members of a racial group does not give the intelligence rating of the race. The psychologist would scarcely maintain that the tests would show a lower rating of modern Greeks than of ancient Greeks; yet the differences in accomplishment are monumental. Moreover, an addition of individual qualities does not give the qualities of the race, neither does an average of individual qualities give it.

Mind does not develop in a vacuum. It develops only in a world in which organism acts on environment and environment on organism. In developing it takes on something of the complexion of the environment, however it may adapt environment to mental life. Given a common environment we have a common basis for comparison. But not unless the environment be really and not merely speciously the same.

By the map it may be the same, but in the psychological life of the inhabitants it may be very different. Part of the environment consists of social contacts, home influences, interests and aspirations; these, whether originating in the individual or in the group, form part of the psychological environment. Moreover, only that part of the environment has influence which meets the mind of the individual, directly or indirectly. The tests show that race differences exist; but they do not show that the differences are attributable to race, if by race is meant biological make-up apart from social influences and the incentives inseparable from social environment.

The Races have not shared the Same Culture Environment

Part of the misunderstanding of the significance of race is due to acceptance of a false analogy between race and individual. It is assumed that a race, like an individual, has its youth, development and old age. The analogy is misleading. As far as we know the races are of the same age. It makes no difference whether we say they are all young or all old. Their possibilities are not exhausted while physical stamina and integrity are unimpaired.

Competition has shifted from physical qualities to social qualities. Not man's physical endowment nor his physical inheritance determine his place in the world to-day, but his social environment and his social inheritance. These are made for him to a much larger extent than they are made by him. Whether I shall have command of the English language depends much more upon when and where I am born and raised than upon my personal qualities, and this holds of the greater share of my accomplishments. When we individualize the races we see that they have not lived in the same sort of world, have not had the same opportunities. Their varied accomplishments can not be attributed solely to innate characteristics. There is no reason to believe that the innate characteristics of Anglo-Saxons to-day are different from their innate characteristics in the first century B. C.; but the difference in the social environment makes of the individual Anglo-Saxon to-day a creature far different from his ancestors of two millennia ago. He does not owe this change to any change in physical heritage, but to a change in social heritage. Only in so far as the respective races have shared a same social heritage do we have ground for making comparisons as to the culture significance of racial equipment.

Relative Independence of Culture and Race

That culture is only casually and not causally associated with race is suggested by the lack of correlation between specific physical qualities and culture. Race characteristics consist of a difference in shape or proportions of nose, of head, in kind and amount of pigmentation, in color and texture of hair, and so on. A peculiar ensemble of these marks off one race group from another.

If these traits in their ensemble have culture significance one would expect to find that some one of them alone has culture significance. But it has not been shown that within any given racial group, Caucasoid or Negroid, the intelligence of the individual varies with elevation of nose, breadth of nose, color of hair or of skin.

If there is no correlation within a given racial group, the presumption is—though it is only presumption—that, taken in their totality, these several qualities have no causal relation to intelligence—probably not more than collars to Christianity.

The relative independence of culture and biological type is shown in the wide variations of culture associated with a given biological type. In the aboriginal New World we have—some physical anthropologists would not accede—a fairly homogeneous racial type, perhaps as homogeneous as any racial type. There is, however, no corresponding homogeneity of culture. From the Eskimo to the Aztecs the changes in culture are as significant as from Eskimo to Africa, or from ancient Rome to modern Rome. Intervening areas support a multiform culture, variations in which appear to be in no wise causally related to fluctuation in biological type. Thus homogeneity of biological type goes with heterogeneity of culture; the specific biological type appears to be only a chance carrier of the specific culture. The causes of the

culture content are to be found in culture and in history, rather than in biology.

The converse is true: heterogeneous biological type is a carrier of homogeneous culture. One finds in Britain, France, Germany, the same racial subtypes, occurring with different frequency in different localities. But the fluctuation in frequency seems to have no relation to the ability of type to carry the national culture. The sections of France in which Nordic type predominates carry Gallic cultures as easily as do localities in which the Nordic type is less frequent. From a study of his physical type no one can infer the culture of the Britisher—neither his politics, his religion, his language, his economic philosophy, nor even whether he belongs to Britain, France or Germany. All over Western, Central, Eastern, Europe homogeneous culture is carried by heterogeneous type. Thus the psychological tests used to exploit race differences really show the independence of race and culture. The group which the psychologist calls Italian, Bohemian, English, Dutch, and so forth, is not a racial group but a culture, or perhaps merely a political group, in which the same race qualities appear as in the other groups, differing only in relative frequency. The psychological tests show that race differences cancel out, can be disregarded. The culture differences of the respective groups persist irrespective of the racial complexion. The Italian rates above or below the Frenchman, German, or Bohemian, irrespective of his racial make-up —the nationals' racial make-up being a matter with which the psychologist has not been concerned and has not even taken note of.

Permanent Race Traits have not been shown

The test of the reality of race traits is their permanence. Otherwise we shall not know whether race is the product of social tradition or social tradition is the product of race characteristics.

It is doubtful whether any "race" characteristics known to us within the social realm can be considered permanent; and if they are not permanent, they are not race characteristics, that is, are not inherent in biological structure. If we take cross-sections of history at chosen intervals race differences appear, but these differences are not constant, neither do they inhere in certain races only, but pass from one to another.

The conservatism of the Chinese has several tens of centuries to serve as witnesses to the permanence of this trait. But we rank conservatism as innately Chinese only because China still continues in that temperament. To-morrow China may right-about-face (if she did not do so yesterday). Had Japan not stirred with new life, we should now be adding that country to the list of peoples in whom conservatism is a permanent quality. Although the vigor of the Anglo-Saxon and the languor of the Negro have many centuries to attest their abidingness, it would be unwarranted assumption to allege that interchange of social quality is as impossible as interchange of complexion. The Ethiopian may not be able to change his skin, but he has shown that he is capable of changing his social life, nor do we know the limit to his capabilities. Comparison of races is made at an arbitrary period of history, the results of the comparison depending upon the century chosen. The comparative rating which we give Celts, Latins, Greeks, Negroes, Anglo-Saxons, varies with the century chosen for making the comparison. Gobineau's endeavor to save the case for race, which he opposes to geographical environment as the decisive factor in social advance, can not rest on the supposition that the purity of the dominant races was destroyed by the infusion of new blood, with consequent degeneration. Even though we admit that such an infusion resulted in

the overthrow of the Hebrews, of the Egyptians, of the Romans, we have yet to explain why the Hebrews rose to eminence in the seventh and sixth centuries B. C., millennia after the Egyptians had acquired world power.

If race brought the Romans into power, why did Roman racial qualities assert themselves only in the centuries following the decline of Greece, and not earlier? British power did not reach its apex until long after large infiltrations of other blood into the veins of Britons. Gobineau, therefore, does not account for the rise and fall of races, nor for the differences in race achievement in different centuries.

He fails, moreover, to take into the reckoning the fact that the story of races is not yet closed. With regard to any given race we must inquire, not merely, What rôle has it played in history? but also, What qualities will it exhibit in the long run? Japan was regarded as inferior to China, being but a feeble borrower of Chinese culture. Now that Japan has liberally borrowed from Western Europe, China, when she attempts to get the stride of European civilization, may have occasion to look up to Japan as her superior. Or will China maintain her own civilization, and Japan again have cause to look up to China—a Japan ruined by that same civilization which made her a modern country?

For all we know, some accident of external influence may have given rise to the culture differences which some would assign to race as a cause. Anglo-Saxon civilization would not have become what it is save for the historical accident of contact with Greco-Roman culture; though had it not been Anglo-Saxon culture it would not have responded as it did to these civilizing influences. Though its opportunity made it, it made its opportunity by accepting it and profiting from it. The people themselves must decide whether, as a result of new external influences, they will take new trend.

Though there are many similarities in reaction, no two groups of peoples have decided in identical manner this matter of utilizing opportunity. Germans have responded to the stimulus in one way, Anglo-Saxons in another, French in still another way. Each according to its bent works out its salvation or refuses to strive for salvation.

Ultimately the determinants of social development lie within the group and its environment, however much the development may be deflected by time and circumstance.

Though we can ascertain what a race has done in the past—and its accomplishments differ with each century—who can say when the group or race, responding to new external influences, or self-impelled, will take new trend and violate our fondest anticipations? The Negro may be moving more slowly toward the goal and be lingering behind the Anglo-Saxon, but is it not possible that he is moving more surely toward it while Anglo-Saxon civilization may be headed in the wrong direction, be on a tangent, and sure to miss the goal though certain to pass close to it? Each race can change the trend of its development. Each has a measure of self-determination which permits it to create or to destroy. It has the power of choice; and choice is elimination of the old as well as selection of the new. As the fulness of life falls within its purview so does the poverty of life and even suicide. The germs of greatness or ruin lie within all races, and we do not know the limits to their respective potentialities. Race qualities can not be finally determined until the race has run its course and then only in so far as the opportunities of the respective races have been equal, only in so far as the human experiment has been carried on under same or similar conditions by all races. In this respect races are comparable with individuals.

Since nature has not provided and laboratory and history does not record any conclusive experiments as to the

capacities of the races, positive evidence of race inequality is lacking. It is not race which handicaps individual and group or gives them impetus, but the social environment of individual or of group.

Other biological forces impinge upon the individual, but race is no handicap. Social, traditional, educative factors handicap or spur on the individual, not the biological factor of the race characteristics which happen to be associated with these social forces. If biological forces determine social development it is through some other medium than that of race.

Origin of the Interest in Race Superiority and Inferiority

The factors responsible for race are morphological or physiological, hence not subject to fluctuations owing to social currents or social interpretation. Yet considerable social importance attaches to race. Conviction of race superiority is largely the creation of peoples self-conscious in the presence of other races or cultures. The Hebrews attached little importance to race, since for them there were but two important divisions of mankind, the Chosen People and the Gentiles. The earlier Greeks made a similar dichotomy, using language rather than religion as the severing line. European thought displays no interest in race until the time of Camper, who noticed that the Ethiopians represented by Italian painters were remarkably Italian in feature, being in fact merely the Italian type painted black. Then came the distinctions of Linnaeus based on color, followed by those of Blumenbach and those of Retzius with emphasis on head-form. The classifications are from a chosen point of view designed to serve a specific purpose. This, perhaps, must be the case, but the purposes have little in common. The Hebrews are interested in religious differences, the Greeks in language and culture differences, Camper is looking for the proper anatomical or morphological make-up. The earlier physical anthropologists of the nineteenth century are looking for measurable proportions which mark off one people from another and will serve for archeology as well as for contemporary ethnology. After 1870 the race question is subservient to nationality. Broca, the veteran French anthropologist, sees the Germans as largely Slavic in composition. Virchow, the veteran German anthropologist, must needs controvert this by way of a mass of testimony to the contrary. Both are making offerings at the altar of nationalism.

With the progress of Darwinism during the past half century the compelling motive has been the subordination of race problems to the evolution hypothesis and the arrangement of races in a hierarchy.

Hence the feeling that the races can not be of equal capacity, since their accomplishments are so diverse. There must be higher, lower and intermediate. European peoples, being in the ascendancy, assume their physical type the supreme one, other types representing degeneration or primitiveness to the degree that they depart from the Caucasian type, though, as a matter of fact, the European type probably shows more "degeneration" than does any other.

If one grants the truth of the assumption of European superiority much can be adduced in support of it; but if one refuses to start with such an assumption it is exceedingly difficult to show the innate superiority or inferiority of a given race. It is not the correlations of race with intelligence quotient which has elicited the inference of race inferiority or superiority, but the inference has elicited the correlations. Had interest centered in the correlations they would not have stopped with race, and certainly would not have stopped until race type had been distinguished from nationality. If we read history and ethnology

aright, to assign a preeminent value to race is to confuse form with function, to assess a thing according to appearance rather than according to performance.

Summary

To sum up our findings regarding race: Potential function is as important as actual accomplishment and can not be left out of the reckoning.

Though races differ in accomplishment this difference is not constant through the centuries. It fluctuates as the culture life of neighbors changes, and independently of changes in the physical type of the group in question. If we view human life from the larger perspectives of time and place there is no reason to conclude that the potential functional or potential accomplishment of one physical type is above or below that of another. To conclude that races have different psychic potentialities one must rule out historic opportunity. This we can do only to a limited extent, if at all. So far as we can do so, the evidence is in favor of the thesis that race potentialities are not inherently different. Least of all can tests of individuals be taken as equivalent to tests of the qualities of the race to which those individuals belong. The physical differentiae of race are, for the most part, like beauty, only skin deep. Remove the epidermis and in most cases it becomes extremely difficult to distinguish races by any physical criteria.

So it is with psychic and social differences. Relieve people of accumulated historic, social and psychic influences, and the races stand out as essentially alike in potentiality.

The evidence of experimental psychology is largely negative. The differences between races shown by laboratory tests are small, and when we rule out interest and previous training and experience we are not sure that any differences inherent in race exist. The sense discrimination of the savage is practically that of the civilized man, that of the Negro does not differ from that of the Caucasian, that of the Oriental is like that of the European. No intelligence tests have been devised which bring within the same realm for comparison on an equitable basis the civilized man and the savage. Tests revised on the basis of those designed for use with school children of the lower grades show differences among European nationalities. But these national differences have not been correlated with physical differences.

The psychologist who has conducted the tests has not ascertained whether the individuals from different national groups are of different race (or of different racial sub-group), though in all probability many of the South Europeans tested are of different sub-race than the North Europeans tested. Chinese and Japanese rank high in intelligence tests. Negroes rank below whites, but how much below them depends upon the section of country in which they live, both absolute rating and relative rating being higher in those sections of the country in which the social opportunities of negroes more closely approximate those of whites.

By the test of behavioristic psychology what a race is is equivalent to what it does and can do; race qualities can not be inferred from the qualities of the individuals who compose the race, for the character of the group seldom is either the average or the sum of the characters of the individuals who compose it. Only when we test races living under like conditions do we have comparable data. Since the accomplishments of the respective races fluctuate considerably through the centuries, we have no reason to believe that one race differs from another in innate psychic equipment.

THE INFLUENCE OF THE WEATHER ON HUMAN CONDUCT

By Dr. EDWIN G. DEXTER
U. S. VETERANS BUREAU

SOME years ago in the course of a discussion of school discipline with a group of teachers, one of them asked me why it was that during some kinds of weather the children "cut up" so.

That I thought was an easy one and blandly proceeded to pass on to something of real importance after having mentioned rainy day, lack of exercise, windows shut, etc., etc., with the air of one who feels that he has been unnecessarily interrupted. But it wouldn't do at all. They set upon me in a body. There was something in it, whether I believed it or not. Some days everybody was on edge and it was the weather, but I hadn't hit the nail on the head at all. I had distinctly lost caste in that community for not being up on my subject.

But I decided to get up on it, if there were any possible way and save myself humiliation in the future. As a result, the question of weather influences has been a kind of knitting work with me ever since; not climate—but weather, pure and simple: those day-to-day fluctuations in meteorological conditions which we all know so well. It is true that if any one of them becomes chronic —as heat or cold—it constitutes climate; but that was not what interested me. Whole libraries had been written on climatic effects, but who had ever said anything about those of the weather?

After a lot of browsing around, I found out. Some of the most eminent authors of all time had written on the subject: Shakespeare and Southey and Walt Whitman and Thoreau and Wordsworth and Byron and Tennyson and Dickens and Victor Hugo have touched upon the influence of the weather on human conduct, not to mention many other lesser lights.

If such men as these had made record of the thing, I was all the more willing to take my hat off to a bunch of schoolmarms in a remote county in Colorado, for that is where they had made their observation on the hopefuls of the nation.

But, you say: "When did Shakespeare and the rest of the authors you have listed ever mention such a thing? And what did they say about it?"

Shakespeare hinges the entire plot of Romeo and Juliet on the effects of a hot day. In the second act of that play he puts these words into Benvolio's mouth:

> I pray thee, good Mercutio, let's retire:
> The day is hot, the Capulets abroad,
> And if we meet, we shall not 'scape a brawl,
> For now, these hot days, is the mad blood stirring.

And again in Henry IV:

> But look you pray, all you that kiss my lady peace at home, that our armies meet not on a hot day.

Southey says:

> I miss the sun in heaven, having been upon a short allowance of sunbeams for the last ten days; and if the nervous fluid be the galvanic fluid, and the galvanic fluid the electric fluid, and the electric fluid condensed light, zounds! what an effect must these vile, dark, rainy clouds have upon a poor, nervous fellow like me, whose brain has been in a state of high illumination for the last fifteen months.

Byron confesses:

> I am always more religious on a sunshiny day, as if there were some association between

> our internal approach to greater light and purity, and the kindler of this dark lantern of our external existence.

But, without more citations, E. O. Kirke, writing in the *Atlantic Monthly*, has summed the thing up as follows:

> With Wordsworth and Tennyson began what might be called the weather cult: that is, the entire impenetration of the theme and the motive with the moods of the atmosphere. Dickens was perhaps the first of the modern writers to press fog and rain into his action as characters, powerful as those of flesh and blood; but this plan has been carried to its limit in certain books of Victor Hugo's, Pierre Loti's, Black's and Craddock's.

But these, you say, are men of genius. They are different. How about us humdrum denizens of an everyday world? Does it affect us that way?

According to the teachers I have mentioned, it evidently does. But how find out? We do not often jot down our impressions of such things. There must be a way. And there is.

It is true that we do not jot down our impressions, but if our conduct becomes sufficiently abnormal somebody else jots down his impression of us and makes it a matter of record in the police blotter; and if we study that carefully enough we can find out just how many of us were acting abnormally on a given day, or on all days for that matter. Then if we go to the trouble to determine what the weather was on a given day, or on all days, and make the proper tabulation, we can find out whether more people were acting abnormally under certain conditions of weather than under others; and, incidentally, determine whether Shakespeare and the rest were right in their deductions.

To illustrate.

The records of the U. S. Weather Bureau show, based upon observations of fifty years or more, that the average number of days each year at New York City characterized as clear is 107, while the average number on which there is some precipitation is 125; *i.e.*, 29 per cent. of the days at New York City are clear and 34 per cent. are more or less rainy. The rest are cloudy, but without precipitation.

That being the case, we might reasonably expect that of all peculiarities of human conduct for the inhabitants of New York City, 29 per cent. would have occurred on clear days and 34 per cent. on rainy or snowy days, *unless the character of the day* were an influencing factor, for this was the only condition of the environment that changed simultaneously for all. When one had a rainy day, all did, and when one had a clear day, it was a clear day for all. Such things as poor coffee at breakfast and dropped collar buttons and automobiles that refuse to start and the hundred and one petty annoyances that influence conduct are distributed pretty well through, and do not happen for everybody at the same time, as the rainy day does. The question then really is: Given the twenty thousand days covered by the Weather Bureau's data and the millions of people in New York City, can we say whether a man is any more likely to make a fuss about the poor coffee or to tip over the dresser in the hunt for his collar button or get profane about the automobile on a rainy day than on a clear day? In other words, is a lost collar button, plus a rainy day, worse than a lost collar button, plus a clear day, so far as its effect upon the conduct of the loser is concerned?

As to mere collar buttons, we can not tell, since they are not matters of record, but when it comes to exasperating circumstances of such a sort as to get one into the hands of the police the thing is quite possible though somewhat laborious. The police record will tell you how many were arrested on any given day in the last fifty years for any given offence, and the records of the Weather Bureau

will tell whether that day was clear, partly cloudy or cloudy and whether it rained or not. That leaves the question merely one of mathematics. As I have already said, it rains more or less on 34 per cent of the days at New York City. If for a long enough period of time to eliminate the accidental error common to all empirical problems, the total number arrested on rainy days exceeds 34 per cent. of the total number arrested on all the days of the period covered, both rainy and clear, then the rainy day has somehow done it, for there is nothing else that could. We have so many people in the great metropolis that the accidental may be completely ignored. Therefore, any mass variation in conduct, concomitant to variations in the meteorological conditions, are due to those conditions.

So far, so good; the weather is not merely rain and shine and heat and cold. There is a lot more to it. There is the wind that has set people on edge since the dawn of nerves; there are constant changes in relative humidity and barometric pressure, things which Shakespeare probably never heard of, but which after all may have a lot to do with it.

Those same records at the Weather Bureau that told us how many rainy days and how many clear days there are in a year also tell us the mean temperature, humidity, barometric pressure and wind velocity for every day for the last fifty years, the only trouble being that they do not publish them. You have to go there and dig them out. That is precisely what I did—not for the whole fifty years, but for twelve—long enough to form a valid expectancy curve—and when the job was over I had the mean temperature, humidity, barometric pressure and wind velocity, the character of the day and the precipitation for each of the 4,383 days of the twelve years.

This expectancy curve was based upon the percentile occurrence of each definite meteorological condition—for temperature each five degrees; for humidity each five per cent.; for barometric pressure each tenth of an inch; for movement of the wind each fifty miles for the twenty-four hours; for precipitation each tenth of an inch, and for character of the day the three divisions of clear, partly cloudy and cloudy.

You would agree with me, I presume, that since one seventh of all the days are Sundays, one seventh of everything that occurs will occur on Sunday unless there is something peculiar about Sunday to make them occur otherwise.

All right. If one seventh of all the days have a mean temperature between 60 and 65 degrees Fahrenheit, one seventh of everything that occurs should occur on days when the temperature is between 60 and 65 degrees Fahrenheit, unless there is something peculiar to that temperature which makes them occur otherwise. If that be true for the temperature group 60 to 65 degrees, it is true for every other temperature group, and for every other one of the fifty or more meteorological groups arbitrarily chosen. In other words, the percentage of occurrence of a meterological condition gives the percentage of expectancy for any peculiarity of human conduct under that meteorological condition.

So much for expectancy. How about occurrence?

This took me wherever a record of human conduct for New York City was kept in the form of a daily tabulation, for it was necessary to know the exact date of the abnormal act in order to determine the meteorological condition under which it occurred.

For the twelve years covered by the study, the police records for the city of New York showed 39,761 arrests for assault and battery; that is, for that number (3,134 of whom were women), the "mad blood" had stirred to such an extent as to get them into the hands of

the law. During the same period 3,564 (2,467 males and 1,097 females) had been placed under surveillance by the police in initial attacks of insanity. Of suicides (and unsuccessful attempts) the police records showed 2,946 for the period.

Arrests for drunkenness were shown to be 44,495.

But the police blotters are not our only records of human conduct. The records of certain public schools gave 108,020 absences and 14,083 cases of discipline for various misdemeanors, and those of the City Penitentiary on Randall's Island 3,981 more of the latter.

To show the influence of weather conditions on health, a portion only of the twelve-year period was covered, and it was found that 75,486 persons had been treated in the outpatient department of the Roosevelt Hospital; 191,137 single day's absence from duty by members of the City Police Force were recorded, and 74,793 deaths were reported for the city; in all more than 550,000 separately recorded human events with the exact date of each, and by reference to the weather data already discussed, the exact meteorological conditions under which each occurred were determined.

It is unnecessary to describe the method of tabulation followed other than to say that for each peculiarity of conduct studied, *i.e.*, assault and battery, suicide, drunkenness, etc., two curves were plotted: Expectancy based upon the percentile prevalence of definite meteorological conditions (the same for all), and occurrence based upon the percentile prevalence for each condition of the abnormality of conduct being considered. If 6 per cent. of all the days showed a mean relative humidity of .75 to .80 and 9 per cent. of all suicides occurred under those conditions of relative humidity, suicides were 50 per cent. in excess (9 per cent. = 100 per cent. + 50 per cent. of 6 per cent.), and so on for them all.

The results show conclusively that Shakespeare and the rest were right.

As to "hot days" and "mad blood," had Mercutio but followed Benvolio's sage advice, the plot might have been despoiled of all its tragedy, for our study showed an excess of arrests for assault and battery of 69 per cent. for men and exactly 100 per cent. for women—or double the expected number—on days when the mean temperature was between 80 and 85 degrees Fahrenheit. The curve is so regular as to leave no doubt of its validity, starting in with a deficiency of 50 per cent. at 10 degrees F., reaching normal (the expected number) at 60 degrees F., and ascending rapidly as the heat increases to the excesses mentioned above. But at this point (*i.e.*, 80 to 85 degrees F.) a strange thing happened to the curve. For the temperature group 85 to 90 degrees F. it suddenly drops, for the women to an actual deficiency of 30 per cent. and for the men to an excess of only that magnitude. Seemingly, something more is necessary for a fight than mere emotional disturbance. One must not only feel like fighting, emotionally speaking, but also feel like fighting, physically speaking, if real blows are forthcoming, and it would seem that the excessive heat of 90 degrees F. had effectively robbed everybody of the latter. Doubtless, if it were of mere profanity that we had a record, and not blows struck, the results would be different.

In the case of drunkenness, the effects of the hot day are almost diametrically opposite to those for assault. Here the curve starts from excess of 40 per cent. at the temperature of 10 degrees F. and runs down, with minor fluctuations, to a deficiency of 36 per cent, at 85 degrees F. This was a distinct surprise to me—though the whole study was full of surprises—for I had lived a number of years in the tropics and found it to be the prevailing opinion that one does not

"carry" his liquor there as well as in colder regions.

But it is certain that the low temperature booked the drunks in New York City. Several influences may have weight here. Our long winter evenings are more conducive to conviviality than are the shorter ones of summer; but I am wondering if there is not a suggestion here to those interested in the solution of our liquor problem. Other phases of the question of weather influences—not discussed here—seem to show that during low temperature the reserve energy of the body is relatively deficient. This would affect the demand for a stimulant. A "bracer" is taken when *needed*, and for many a "bracer" means a "drunk." We may, I believe, with justice, conclude that many of the habitués of the police court as prisoners struggle against their tendencies to drink, knowing the consequences. When vitality is excessive, they do so with success; for days and, perhaps, for weeks they are winners, but finally the time comes when the fight is too severe, and they succumb. That was on the day when the vitality was at its lowest ebb, and the cold contributed to that condition. A few glasses of whiskey would remedy all that, and it did so. What cared the poor fellow what Arctic explorers have said about the effect of alcohol upon the system in the long run? He was cold; he was weak. The stimulant would give him immediate, though temporary, relief. He took it, and our figures show the result. Who can say how largely the drink problem is one of better heated tenements, of warmer overcoats and of more nourishing food!

Now we are between the devil and the deep sea. If we want to keep from fighting we must take care on a hot day, and if we want to keep sober we must look out on a cold one. But there is one consolation; if we want to commit suicide neither one seems to have anything to do with it—at least until we reach that deadly point of 90 degrees F. as a mean for the day.

Suicides were found to be precisely normal in number at a temperature of 15 degrees F. and again at 75 degrees F., and between those two points the curve fluctuated in such a manner as to indicate little or nothing. At 90 degrees F. it took a jump to + 45 per cent. for men and + 70 per cent. for women, but there were so few cases involved at this extreme of the curve as to lessen its value.

So when it comes to committing suicide we may do it on any kind of a day, so far as the thermometer is concerned, without violating the rules of this paper.

But when it comes to certain other meteorological conditions, we must take care. For instance, we must consult the barometer, to do it according to form.

For every barometrical reading above 29.80 the number of suicides was deficient, running down to — 88 per cent. at 30.30, while for every reading below 29.70 it was excessive, averaging + 176 per cent. (nearly three times the expected number) for all readings below 29.60.

Just what this means it is not easy to say. Certainly it is not a matter of mere atmospheric pressure, for every time a New Yorker goes to the Catskills or the Adirondacks he experiences a greater lessening of pressure than is shown by the extremes mentioned above, seemingly with no suicidal effects. It is, however, a well-known fact that low barometric readings generally precede storms, and here we may have the explanation.

If so, they had the thing over before the storm really struck, for in a most surprising way, suicides chose the most delightful of all our weather conditions for their fatal act. The month of May is their favorite, with an excess of 90 per cent. for the women and of 12 per cent. for men. Twenty-five per cent. more chose dry days for the act than

rainy days, while 22 per cent. more chose clear days than those characterized as partly cloudy. The number choosing cloudy days was precisely normal.

Wind alone among the more evident meterological conditions proved an exception to the seeming desire to leave the world on a pleasant day. Excessively high winds proved deadly. Starting in at — 80 per cent. at wind velocity of 2.5 miles per hour the curve rises almost without fluctuation to + 200 per cent. (three times the expected number) for days on which the average hourly movement for the day was fifty miles.

This seems as it should be.

But how account for the excess of suicides on the most delightful days of the whole calendar? To me the only plausible hypothesis is that of contrast. Investigation has seemed to prove that very few suicides are committed on the "spur of the moment." The act is generally premeditated and its consummation deferred, sometimes again and again. We can hardly doubt, either, that it is dreaded, and the hope entertained, even to the end, that it may not need to be. During the winter months that hope might be centered in the belief that when nature smiles with the spring sunshine all will be well; on the gloomy day, when the morrow comes with its exhilarating brightness, the present cloud of unhappiness will be gone. The love of life is still strong, and the grave can not be sought while there is still hope for better things.

Spring comes with all its excess of life, and the morrow with its brightness, but do not bring to the poor unfortunate, unable to react to these forces as of yore, the hoped-for relief. He thinks of other springs when the bluebirds sang happier songs and of other sunshine which had set his blood a-tingling. The drowning man had waited long for the straw; it came and he clutched it, but it sank beneath his weight. Dante felt the force of it when in his "Divine Comedy" he wrote:

> No greater grief than to remember days
> Of joy, when misery is at hand.

And Tennyson expressed the same thought in "Locksley Hall":

> Comfort? comfort scorned of devils! this is truth the poet sings,
> That a sorrow's crown of sorrows is remembering happier things.

So much for voluntary death.

How about the other kind?

This takes us into a brief discussion of body energy. Health means a degree of body energy based upon metabolic processes, the activity of which has been determined by natural selection through a long period of time. When those processes are normal, a sufficient modicum of energy is developed for all the vital activities of life—respiration, circulation, digestion, assimilation and excretion—plus a reserve of varying quantity available for the higher and more recently acquired activities of the race, such as the mental, the emotional, etc. When the production of body energy is insufficient for the demand of the vital processes, ill health and possibly death ensue. Seemingly, when the production of energy is in excess of that required for the vital processes it is available as excess energy and affects conduct in its accepted sense. A horse fed oats in the stable for a month is likely to be frisky. But oats are not the only thing that will make a horse frisky. The weather will do it. I once studied the occurrence of several hundred "runaways" with respect to the weather and found this to be true.

From the standpoint of energy, there is no difference between the "runaway" for a horse and a fight for a man or perhaps naughtiness for a child. Each must "feel his oats" before he does it. Does the weather make us feel our oats?

In other words, do varying meteorological conditions affect the production of body energy?

We have four sets of figures which have a bearing on the answer to this question: absence from school on the part of pupils; absence from duty on the part of policemen; attendance at the hospital clinic, and death. The first two and the last would, in general, be due to low vitality. There is no doubt as regards death, save in cases of accident, and as to the others contagious diseases and perhaps circuses might have to be reckoned with, but in general the law would hold there.

With attendance at the hospital clinic, I am inclined to think that the reverse is true; that those who are patronizing the clinic—and the records show the average number of visits on the part of such to be four, made at intervals of some days—only attend when they feel equal to the inconvenience of such a visit; that is, on the best days which they experience. If this be true, we should expect the curve for hospital attendance to run counter to the other three. And that is what it does.

It would be too long a story to go into the detail of it all, but in general temperature seems to have little effect on health until we reach the highest degrees, when everybody wilts. It is not strange that moderate degrees should not be felt, since the temperatures in which we live—except the highest—are artificially controlled. One might be sick for days in the dead of winter without knowing that the thermometer outside registered zero, except for the frost on the window. Extremely low barometric pressure is deadly, with a similar effect, though to a lesser degree, for extremely high readings. Moderate atmospheric pressure is healthful. High humidity is disastrous, while the same is true for virtual calms and also for the other extreme of wind movement. Neither the character of the day nor precipitation has any marked effect.

No one of the meteorological conditions studied more plainly differentiates the different classes of data into contrasting groups than does the wind, and no condition presents more anomalous and unexpected effects. Particularly is this true for movements of less than one hundred miles for twenty-four hours—that is, virtual calms.

Misconduct cases in the public schools on such days were but 50 per cent., and in the penitentiary 80 per cent., of the expected number; women arrested as insane 34 per cent., men 67 per cent.; suicides 62 per cent.; arrests for drunkenness 78 per cent.; for assault and battery, women 45 per cent. and men 89 per cent. With death we reach the first excess over expectancy, with 104 per cent. Policemen off duty 105 per cent.; sickness (hospitals) 114 per cent., and absence from school 314 per cent.

The striking thing about the curves on which these figures are based is the sudden change which takes place in the occurrence of nearly all the activities (or cessation of activity as in the case of death) with a slight increase in wind.

Calms are in a class by themselves so far as wind effects are concerned. During their prevalence certain phenomena suddenly increase in number, while others drop almost to a vanishing point. Those in excess are absence from school, absence from police duty, sickness and death.

But absence from school means sickness, absence from duty the same, and death the same at its maximum—that is, depleted vitality in every case.

Those human events which were deficient during calms were, without exception, misconduct cases: arrests every one of them, either by the police or school authorities, and due for the most part at least to a surplus of energy.

Let us see if that is not so.

In the public schools, sins of commission, rather than sins of omission, are usually the occasion of bad marks in deportment. It is usually the active, energetic boy, the one with vitality to spare, who gets the demerits. The anemic youngster may never stand at the head of his class, but he is very likely to delight his fond mamma with a mark of 100 in deportment. If that be so, and I speak with authority upon this point, if upon no other, disorder in the schoolroom is an active thing and an evidence of excessive vitality. With the penitentiary inmate I have had less experience, but upon *a priori* grounds would argue that what is true for the child in questions of deportment would not be radically different for the adult. In fact, the wardens in charge, upon being questioned on the matter, gave it as their opinion that the prevalence of disorder bore a pretty close relation to physical health, varying directly with it; that order was only observed through evidence of superior force on their part; that a sick person was always a good one, but that with return to health, conditions were frequently very different. We may, then, conclude that in the penitentiary misdemeanors are evidences of excessive vitality.

With persons arrested for the crime of assault and battery the same is, I believe, demonstrably true. One might feel like fighting, and perhaps more frequently does feel so, when possessed of "that tired feeling" which is the fortune of patent medicine venders, but to *feel* like fighting without doing so never brought a man before the police judge for the crime which we are considering. There must be both the inclination and the consciousness of strength to back it up before one would be likely to figure in this class of data.

In the case of the next class, that of arrests for insanity, we shall take the word of the psychiatrist that acute mania increases with any condition which tends to augment the output of nervous energy. The daily fluctuations in strength which all have experienced are not so much those of physical, as of nervous energy, if the distinction may be made, and with persons having tendencies to mania the results would be those which our records showed.

Drunkenness and suicide are not so evidently manifestations of superabundant vitality—though, as I have already shown, the latter is excessive under the most exhilarating conditions—yet with these possible exceptions it would seem that during calms those life phenomena which normally are due to an excess of vitality are deficient in number.

Why?

Merely, it would seem to me, a question of ventilation. Not of opening a window to let in some good air, but perhaps of opening a window and finding no good air to let in. Remember this study is confined to New York City. And then remember what New York City is. Some millions of people burning up oxygen and some hundreds of thousands of furnaces and fires of smaller dimensions doing the same thing, all pouring forth carbon dioxide without sufficient vegetation to reverse the process. What else could be expected, without a little breeze to carry it out to sea, or over to Jersey where the trees can take care of it? Studies made in the city of Manchester, England, to determine the relative prevalence of carbon dioxide on calm and on windy days show that the quantity is several times greater under the former than under the latter conditions. With an excess of that deadly gas, the production of body energy slows up with the result that we have noted. So, if you live in a large center of population take to the woods on a calm day. It is safer.

In conclusion, it seems safe to say that Shakespeare was right, not only in his

allusion to the deadly effects of a hot day, but in his many other references to weather influences. And so were the others who have embodied their impressions in literature. Once more, all honor to the seer who does not need to follow the empirical method, for after all research is seldom more than an attempt through scientific process to verify or disprove somebody's impressions.

The varying meteorological conditions that we call weather do influence us to marked degree, seemingly through a direct effect upon the metabolic processes of life. Seemingly, too, women and children are more susceptible to them than are men.

We can not change the weather, but we can perhaps adapt our activities somewhat more to its decrees, if only the latter be known.

In our public schools are more than twenty million children under controlled conditions. We have shown that under certain weather conditions so much energy is produced that it blows off in misconduct.

But why in misconduct?

It is a question of energy. Why not open some safety valve on such days and let the surplus escape?

A longer recess might do it or calisthenics or anything else that will burn up the excess.

But, you say, must the teacher consult the weather report before arranging the schedule for the day? Not that exactly, though it may come in time. But when we as fathers and mothers and teachers and common everyday individuals get to be as wise as that group of teachers in Colorado and then just so much wiser as to lead us to act in accordance with the facts, we shall not attempt so many impossibilities, either with ourselves or with others.

For:

> . . . a breath thou art,
> Servile to all the skyey influences
> That do this habitation where thou keep'st,
> Hourly afflict: . . .

"Measure for Measure," Act III, Sc. 1, 8–11.

THE TREND OF PUBLIC HEALTH WORK: IS IT EUGENIC OR DYSGENIC?

By Professor MAZYCK P. RAVENEL
UNIVERSITY OF MISSOURI

NEVER before in the history of the world has there been such an intensive campaign to prolong life. Our success in the control of communicable diseases has been outstanding along every line, except for the respiratory infections. Education in personal hygiene is making good advances. New discoveries in problems of nutrition and the value of foods have been revolutionary. Physical education has been so magnified that it threatens to overshadow mental training in our schools and universities. Along with these advances, there has been an equal improvement in our environment. The development of transportation, cold storage and other methods of food preservation have taken away from the world in general the specter of famine. Along every line the stage has been set for such rapid increase in population as no one ever before thought possible. Success has attended our efforts. Our increases in population and resources are being preached from the housetop, and if success means the accomplishment of our objects, we certainly have the right to boast. In the midst of rejoicing by sanitarians, humanitarians, business men and powers which need "cannon fodder" a note of question is creeping in, coming chiefly from biologists and a certain class of economists. Can we accept the dictum of Adam Smith that "the most decisive mark of the prosperity of any country is the increase of the number of its inhabitants?"

Increase in population according to this idea means progress. Ambassador Bryce once stated "that the ultimate test of every kind of advance is happiness." Malthus pointed out long ago that increase in population that was out of proportion to the increase in food supply would lead to anything other than happiness. His doctrine was received with incredulity and worse, but each year proves his wisdom and foresight, and there is a constantly increasing number of studious men and women who are accepting his views and advocating measures based upon their practical application.

We do not know how long man has inhabited the earth, but we do know that in 1800 the population of the world was approximately eight hundred and fifty million and that this number was doubled in the last one hundred years. Taking the smallest estimate, which is scouted by almost all scientists as being twenty-five thousand years, we can say that it has taken only one hundred years to double the population which it required twenty-five thousand years to produce. Knibbs estimates that the population of the world doubles every sixty years at the present rate of increase, and if this is true, within three generations from the present our population will reach seven thousand million, or two thousand million more than the estimated number for which the world can produce food.

Preventive medicine as we know it today is of recent birth. While Pasteur began his publications about 1855 to 1860, his discoveries became generally known and utilized less than fifty years ago. The application of his discoveries has meant almost more to big business than to humanity. Vast areas of tropi-

cal and semi-tropical countries which only a few years ago were sealed against exploitation are now open for the production of rubber, coffee, tea, spices and other products of world-wide consumption. The result has been that in these areas the population has increased one hundred and five million. Forty years of British rule in Egypt saw the population of the Nile Valley double. In approximately the same length of time India has added fifty million to its already overcrowded population, and the most expert students now question whether or not the masses in India are better off than they were before British rule, yet we know that the British have introduced modern methods along practically all lines. Approximately the same statement can be made of many parts of the world, and the estimate of Knibbs for the world has been far surpassed in many countries. In the Philippines the increase from 1908 to 1918 was at a rate which would double the population in twenty-three years. The population of Java has multiplied eight times in a century. In Porto Rico, where the birth and death rates were approximately balanced, we have since 1900 reduced the deathrate to eighteen, while the birth-rate has risen to thirty-seven per one thousand. Next to Java, this is the most densely populated agricultural area in the world—nearly four hundred to the square mile. Between 1800 and 1916 the population of Europe increased from one hundred and eighty-seven million to four hundred and sixty-five million.

We are naturally more concerned with our own country than with the rest of the world, in spite of the fact that our charities are reaching out to every land. The United States increased its population almost twenty fold between 1800 and 1920. For the decade from 1800 to 1810 only 1,932,000 were added, while for the decade from 1910 to 1920 the increase was 13,739,000. The latest estimate by the United States Department of Agriculture is "that after our arable land has increased almost 100,000,000 acres, which appears likely to happen during the next seventy-five years, and if our acre yields of the crops attain those in northwestern Europe, and our diet reaches the pre-war German standards, our nation will be able to support about three hundred million people." That these conditions will be fulfilled is very uncertain. The population of the United States increases by about one million five hundred thousand yearly, while the yield of foodstuffs per acre has shown little or no increase for fifteen years past. Dr. Baker, who has made this study, contradicts Adam Smith and says that "strength is measured more by per capita wealth and welfare than by numbers of people."

From 1804 to 1914 the rate of increase of population in the world was 0.844, which would lead to a doubling of the population in 80.57 years. Between 1906 and 1911, twenty-six of the leading countries of the world increased at a rate of 1.159, which would double the population in a trifle over sixty years. Taking the world population in 1924 as 1850 million, either one of the above rates would lead to saturation of the entire world by the year 2165, approximately two and a half centuries. As far as we are able to judge from the past, and with our present knowledge, it is safe to say that our present rates of increase must fall off as the population approaches saturation. Every year will show advances in sanitary science and in control of diseases of almost all kinds, so that the decrease must come by limiting the birth-rate or by the destruction of life. The birth-rates of practically every country from which we obtain reports is decreasing, in spite of which all our populations are increasing at a rate

which must cause grave concern for the comparatively near future.

The world must live chiefly by agriculture. Consequently, the best distribution of population is that which conforms most closely to resources. Where great differences exist, migration is the only relief, but the necessity of migration means racial jealousies and war, which is not only inhuman, but as we have had recent cause to learn, economic madness. As our population increases, we will be compelled to depend more and more on vegetable foods, and fewer animals will be raised either for food or for transportation, since the land will be needed for vegetable food production.

The history of the world shows that civilized people do not hesitate to take territory from inferior races, with the result that the latter often disappear more or less completely. Striking examples of this are seen in our own country, in South Africa and in Australia.

We can not foretell what future discoveries will bring about, but it is hardly conceivable that such advances in the production of foods will be made as to entirely upset the calculations based on our present knowledge. Making every allowance for increase of knowledge and for improvement in our social, economic and political organizations, Knibbs, the noted Australian economist, calculates that seven thousand million population may be supported, while ideal conditions which are most improbable may possibly allow from nine thousand million to eleven thousand million. With our present standard of living, it is doubtful if the world can support five thousand million people.

The title of my paper would scarcely seem to justify the discussion up to this time, but food is the primal necessity of all living beings, and the discoveries of the last few years have shown us that quantity is of relatively less value than quality in regard to certain contents. It is impossible therefore to consider the welfare of the race without taking into consideration what our present rate of increase is leading to in the way of overcrowding and struggle for existence.

It has frequently been pointed out that the prolongation of life, of which we have boasted so much, has been chiefly in children under five years of age. On the one hand, it has been claimed that the saving of weaklings is bound to affect the future of the race. On the other hand, there are those, notable among whom is Sir Arthur Newsholme, who hold that the struggle of the survivors among those in whom a high death-rate occurs, is severe and leaves its mark. While we may admit with notable statisticians that infant mortality is to a certain extent selective, the predicted compensatory death in early life from the saving of babies otherwise doomed does not occur, since the mortality rate has improved at all ages except the very advanced. Quite a list of world shakers could be given among those who would have been selected for weeding out, if such a system had been in vogue.

The present state of our knowledge does not permit of the formulation of rules for the future, but it is not too early for us to begin a careful study of the situation which confronts us. American beneficence has founded a modern medical college in China, already overpopulated. Highly educated medical missionaries are going to many parts of the world which already have more people than they can support. In a few instances agricultural missionaries are also being sent. The medical section of the League of Nations is collecting data from practically every part of the world and giving the results to all nations. This can not but result in the saving of lives at all ages with an increase of an already superabundant population. America has found it necessary to re-

strict immigration, though many believe that this has not gone far enough. There is some reason to believe that it will cut out at least one source of undesirable stock.

While acknowledging our inability to suggest a complete program for the future, there are certain outstanding facts upon which we should act promptly. The World War gave us our first opportunity for the examination of a large number of our young men. It astonished many to learn that if mental deficiency runs uniform among persons of all ages, there would be 353,210 male defectives in the United States. Supposing the same number for females, we would have more than seven hundred thousand for the country, less than 6 per cent. of whom are cared for in institutions, which means that approximately 94 per cent. of these defectives are at home living without restraint of any kind. Judging from known facts concerning those in institutions of various kinds, it is conservatively estimated that there are between one and one half and two million people in our country who are defective and in need of institutional care, of whom at least one half have heredity to thank for their condition, and who in turn will reproduce their kind. East, who is somewhat pessimistic, estimates that we have "people with no sense worthy the name, defective stock, over five million; people with little sense, scrub stock, twenty million."

The fecundity of this class of people is in no doubt. In spite of a high infant death-rate and a greater amount of sterility, there seems to be no doubt that the subnormal reproduce their kind more abundantly than the normal. In St. Louis among normal families only 4.76 per cent. had eight children or more. As the mental scale went down, the size of the family went up, so that among morons 34.58 per cent. of families had eight children or more, while for all classes of those below normal the average was 19.12 per cent. When we remember the number of criminals who are subnormal, and that subnormality leads to criminality, and when we know that a large percentage of asylum patients are released and recommitted, some of them twenty-eight or thirty times, we are surely not going too far in believing that genuine humanity, as well as common sense, demand that we place some restriction upon these afflicted persons. As far as we are able to judge, the deadly deteriorative character which is so clearly seen in most of these cases can be gotten rid of only by cutting the bearer off, and there is no justice in giving them the same privileges as are enjoyed by the normal. The difficulties in the case are acknowledged to be great, but this is all the more reason for taking hold of the matter promptly.

Recently a more optimistic attitude towards the feebleminded has been taken. The late Dr. Fernald, than whom no one was more competent to speak, held that only about 10 per cent. of the feebleminded are anti-social and vicious. The remainder can be handled and many of them made useful citizens within their class by education and supervision. Those who are trained do not differ markedly from normal people in respect to the number of children they produce. In view of the fact that only about 50 per cent. of the feebleminded are such through the inheritance of defective germ plasm, and that there is a tendency for the inheritable healthy qualities of germ plasm to outnumber and gradually supersede the unhealthy traits, it is possible that the offspring of such people through several generations may improve. For those feebleminded whose condition is due to post-natal conditions, no special precautions are required in this respect, since acquired characteristics are not inheritable. As Professor Conklin says: "Wooden legs are not in-

herited, but wooden heads are." Fernald's estimate of the number of feebleminded is, however, considerably greater than that shown in the draft figures quoted above, if we may apply to the whole United States those given for Massachusetts. In that state, with a population of approximately three and one half million, there are at least sixty thousand intellectually subnormal persons. For the entire United States this would give a figure approaching two million. Quite recently Dr. George K. Pratt, of the National Committee for Mental Hygiene, has emphasized this more hopeful outlook. The 10 per cent. of feebleminded who are vicious is found almost exclusively among the neglected, most of whom, if given a fair opportunity by training and supervision, would lead well-behaved lives. A recent survey in New York shows that only 7.6 per cent. of the jail and penitentiary inmates studied were definitely mentally defective, and the addition of the borderline and dull-normal groups only brought the total to 20.3 per cent.

He endorses the program first proposed by Fernald, which may be summed up as identification, registration, education, training, supervision and permanent segregation for defective delinquents and the lower, helpless group of feebleminded. Sterilization is definitely rejected as a solution of the problem.

In thinking of this subject, too many people are inclined to consider only such evident cases as are more or less apt to come under official recognition. There is, however, a large class made up of people who are often extremely likable, attractive and who are ordinarily free from criminal tendencies. They are, however, mentally incompetent to make a living or to realize the responsibilities of life. They are easily led and sooner or later are apt to drift into lives which bring them into the criminal courts. These people marry—or do not marry—and beget their kind indiscriminately. It is always a matter of comment that so much more is done for animals than for humans. Those who resort to every sort of quackery for themselves and their children demand the best educated veterinarians and use the most modern methods in caring for their flocks and herds. The same thing holds in regard to eugenics. In breeding live stock, the selection of the parents is a cardinal principle. The veriest tyro knows that animals are not born equal. The good livestock breeder selects the best and makes sure that the inferior animals leave no progeny. Only those—and there are none who are competent to speak—who deny the overwhelming influence of heredity deny these facts and use inferior animals as breeding stock. We do not pretend to put the lower animals on the same level with man, but there is no doubt that we could learn some useful lessons if we studied the lower animals and the methods of stock-raisers a little more closely. Religion, race, customs, emotions and humanity all influence us. It is a poor humanity which allows the propagation of the unfit.

Among the remedies for over-population with its many attendant evils, birth control seems to be the most popular at the present time. It is one of the foremost questions in England and has gained great headway in America. It is within the truth to say that it is endorsed by practically all the leading biologists of the country, by many economists and sociologists and some clergymen. In England it has the support of many clergymen of high standing. Some of the arguments for birth control must appeal to every thoughtful person. Every child in a small family is brought up on a higher standard of living, receiving proportionately a greater amount of attention and has opportunities for a better start in life. The argu-

ment that the health of the parents of small families is better does not seem to be entirely sound, but where the choice lies between abortion on the one hand and birth control on the other, this argument may hold true. On the other hand, the objections to birth control are too manifest to be passed over lightly. It is already being practised in one way or another by those best fitted to perpetuate desirable families. Any restriction which would reduce the number of offspring of desirable parentage below the minimum required for the perpetuation of the stock is bad from every standpoint and is more apt to lead to the loss of good stocks than to prevent the perpetuation of poor ones. The preservation of good stocks is immensely more important than the prevention of increase among the inferior.

We do not know enough to speak positively of the advantages of the small family. Many notable persons have been members of large families and have been well down in the long list of children. Sir William Osler was one of these, the youngest in a family of nine. The small family idea proposed by the Neo-Malthusians would have deprived the world of many of its greatest lights. The whole question is bound up with religious, social and economic conditions. It offends certain churches particularly, but generally speaking all Christian churches as well as the Jews condemn interference with procreation. If we believe this to be a true picture of the situation, we must of necessity stand against it, at least until we know a great deal more than we do at the present time.

The answer to the question propounded in the title of this paper is not clear. From the biological standpoint there seems no possibility of producing a superman. We tend to mediocrity through the very fact of the large number of ancestors each of us have. If the best could be mated always with the best, unquestionably we could produce results similar to those seen in the breeding of the lower animals and of plants. Eventually all the offspring would tend to be superior and the superiority would be maintained as long as this type of mating was kept up. It seems impossible ever to expect anything of this sort.

We must conclude, then, that our present measures will continue to save more and more lives. The good and the bad will alike be saved. Our present standards will not permit of any lessening of our attempts to save lives and better conditions, nor do any people exist who would propose a lowering of standards. Within the next few hundred years the problem of overcrowding will have reached a point requiring attention and a change in attitude will almost certainly be noticed.

HOW FOSSILS GOT INTO THE ROCKS[1]

By Dr. WENDELL P. WOODRING

U. S. GEOLOGICAL SURVEY

FOSSILS are the remains or traces of animals and plants that formerly lived on the earth. A footprint, a leaf imprint and a worm burrow are fossils every bit as much as bones and shells. Nor is it essential that these remains be turned to stone. Many animal fossils consist of the same material found in the hard parts of living animals, but other fossils are completely changed to stone or the original material may have disappeared, leaving only a mold. Fossils may be of any age. They may have lived millions of years ago, or they may be only a few years old. An example is shown by the limb bone of a cow that was found partly buried in the ground. The part below the ground was petrified and was as stony as any ancient fossil, but the part above ground was entirely unchanged, except that it was weather-beaten. On some of the West Indian islands stretches of beach can be found that are changed to limestone rock, but the shells and other remains buried in the solid rock are perfectly fresh and the dried skin still clings to some of the shells, showing that the beach was transformed to rock only a few years ago.

At many places fossils are so abundant that they naturally attracted attention long before the rise of modern science. During this period many curious beliefs arose as to how fossils got into the rocks. By some they were regarded as the results of some mysterious force that arose from the earth or the stars. Others thought they were freaks of nature or models discarded by the Creator. And others considered them convincing evidence that at one time the earth was devastated by a flood. One enthusiastic supporter of this belief found some bones that he was convinced were the remains of one of the wicked men whose sins brought upon the world the dire misfortune of the deluge, and he named these remains "The man who witnessed the flood"—at least that is the English equivalent of the Latin name. As a matter of fact it was later discovered that these bones belonged to an extinct giant salamander. Another supporter of this belief concluded from a study of fossil fruits that the deluge began in autumn. A learned professor, who believed that fossils were formed by the earth, carefully described as fossils an amazing array of suns, moons, stars and Hebraic letters that his students planted in quarries. When he dug up his own name the secret was out and he vainly attempted to buy up and destroy all the copies of his book. Leonardo da Vinci, the great Italian artist and engineer, was one of the first to show in a convincing manner that fossils are the remains of animals and plants that actually lived where they now are found. Although some people even now believe that fossils were put in the rocks by the devil to confuse man and others still believe that they are sure signs of wholesale destruction by a world-wide deluge, it is clear that they get into the rocks by natural means—by means that can be seen in operation now.

Every one knows that when animals and plants lie on the surface of the ground after death they gradually decay and crumble. In order to be pre-

[1] One of the Smithsonian series of radio talks arranged by Mr. Austin H. Clark and broadcasted from Station WRC, Washington.

Courtesy of American Museum of Natural History

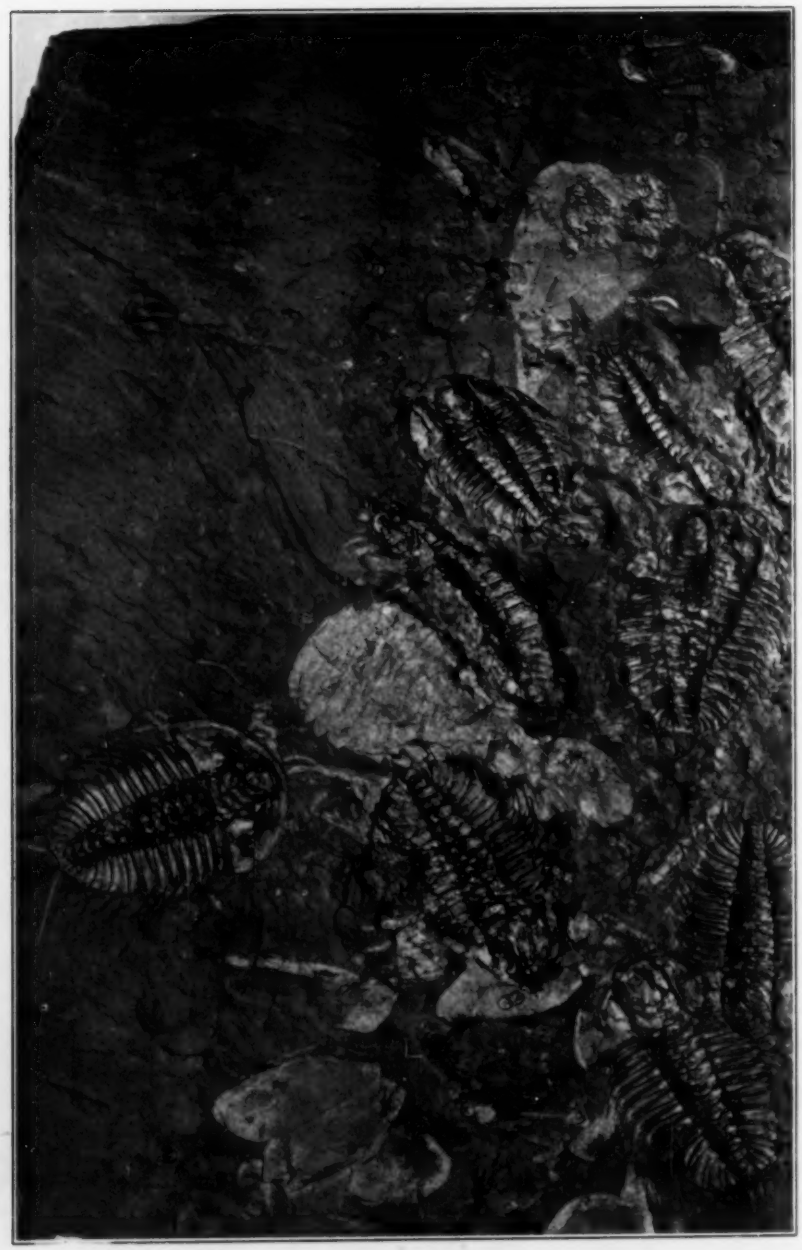
THE ASPHALT POOL AT RANCHO LA BREA, CALIFORNIA

A GROUND-SLOTH IS TRAPPED IN THE STICKY ASPHALT. TWO OTHER GROUND-SLOTHS ARE READY TO DEFEND THEIR COMPANION AGAINST THE SNARLING SABRE-TOOTH TIGERS. IMPERIAL MAMMOTHS AND GIANT WOLVES CAN BE SEEN IN THE DISTANCE. FROM A MURAL IN THE AMERICAN MUSEUM OF NATURAL HISTORY PAINTED BY CHARLES R. KNIGHT UNDER DIRECTION OF HENRY FAIRFIELD OSBORN.

U. S. Geological Survey

A PETRIFIED TREE TRUNK IN YELLOWSTONE NATIONAL PARK

THIS TREE, WHICH IS STANDING WHERE IT GREW, WAS BURIED BY SHOWERS OF ASH FROM VOLCANOES.



Smithsonian Institution

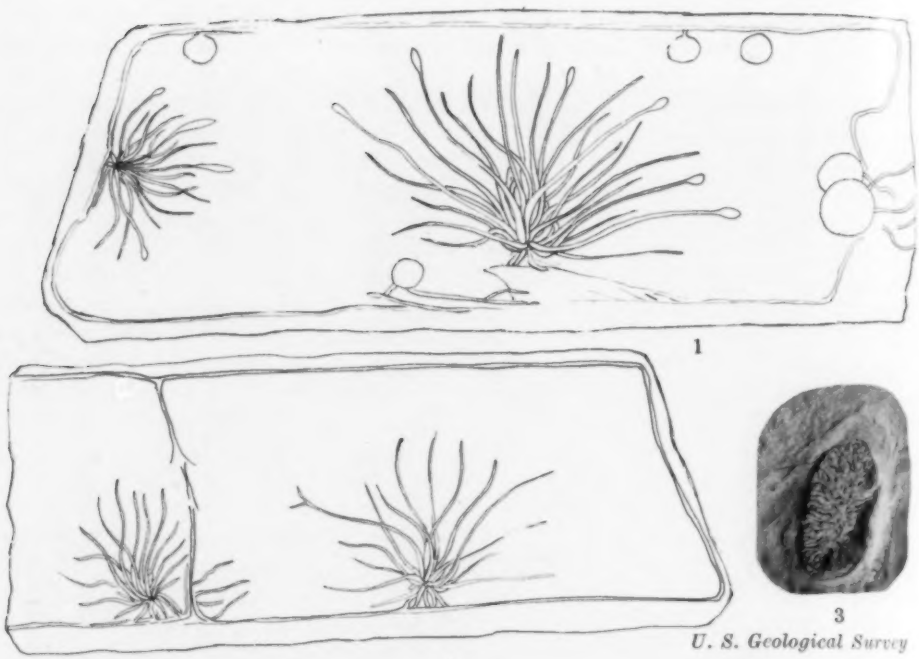
MIDDLE CAMBRIAN SEA ANIMALS FROM BRITISH COLUMBIA

TRILOBITES AND CRABS FROM A FAMOUS LOCALITY DISCOVERED BY DR. C. D. WALCOTT, SECRETARY OF THE SMITHSONIAN INSTITUTION.

served as fossils it is essential that they be buried. Only the hard parts of animals generally are preserved, for the soft parts are eaten by scavengers or decay. Under exceptional conditions the soft parts are found in virtually perfect condition. In the frozen ground of northern Siberia specimens of elephant-like animals, called mammoths, and of the wooly rhinoceros, both of which lived during the Ice Age, are found with flesh, hair and wool preserved. The flesh of these animals can be eaten, although they have been in cold storage for something like fifteen thousand years, which is a record for cold storage meat. The contents of the mouth and stomach of the Siberian mammoths even show what kind of plants these animals fed on. A less perfectly preserved mammoth having parts of the flesh and hair intact has also been found in Alaska. Though actual flesh is found only in these relatively recent fossils, the skin of much older animals may be preserved because it was thoroughly dried before the carcass was buried, and the muscle fibers of some very ancient fish can be recognized on account of the replacement of the soft tissue by mineral matter. When worms and other soft-bodied animals are quickly buried by mud that prevents bacterial decay, they leave impressions that may show not only the surface but also the internal structure. Such fossils are found even in very ancient rocks, but they are rare.

The most abundant fossils are the remains of animals and plants that lived in the sea. No matter whether they live on the bottom of the sea or on the surface, the hard parts of sea animals collect on the bottom after they die and after the scavengers have done their work. There they are covered by gravel, sand or mud carried in by streams and washed about by the sea. Any one who has walked along a beach can see that shells and other remains that are rolled by the waves are badly battered and broken up. Such battered fossils are found in ancient beach deposits. If the remains are buried in quiet water or at a depth beyond the effects of waves the fossils may be as perfect as the same parts in living animals. In the deep ocean basins, where deposits accumulate very slowly, the teeth of giant sharks and the ear bones of whales, long extinct, may even now be only partly buried. Many sea animals and plants die and are buried at the place where they lived. Corals and other reef-making animals and plants are killed by changes in the temperature or depth of the water, or are smothered by mud and sand. Incredible numbers of fossil fish are found in thin layers of rock in California and at other places. They probably were killed by being stranded in shallow bays into which they were driven by their enemies or during storms, just as herring are sometimes stranded by millions in our northern harbors. The decomposition of the stranded fish pollutes the water and kills other sea animals, all of which would become fossils if they were buried before they completely decayed. Complete skeletons of sea mammals—whales, dolphins, porpoises, seals and walruses—generally are rare, for the bloated carcasses float on the water and the bones are scattered, but at places, such as a famous locality in Belgium, many carcasses drifted into a cove and were stranded and buried there. Remarkably perfect sea reptiles showing the outline of the body, which also represent carcasses stranded in fine mud, are found in England and in southern Germany. When any of these deposits that were laid down in the sea are brought above sea level by elevation of the land or by retreat of the sea, the fossils can be seen embedded in the rocks, although the originally loose deposits may be changed to solid stone and the fossils themselves may be completely altered.

TRILOBITES AND CRABS FROM A FAMOUS LOCALITY DISCOVERED BY DR. C. D. WALCOTT, SECRETARY OF THE SMITHSONIAN INSTITUTION.



FOSSIL PLANTS OF EOCENE AGE FROM TEXAS AND LOUISIANA

FUNGI PRESERVED IN PETRIFIED WOOD (FIGS. 1 AND 2), A CONE (FIG. 3).

The bones and teeth of land animals are buried in stream and lake deposits, or by showers of volcanic ash and by wind-blown sand and dust; or the animals are bogged in mud holes and trapped in quicksand. Fossils in coarse stream deposits, like fossils in beach deposits, are worn and battered. At a locality in western Kansas the skeletons of nine peccaries, or American wild pigs, were found crowded together with their heads all pointing in the same direction. These animals apparently were killed and buried by a sand storm. The wind-blown dust deposits of the pampas of Argentina contain many queer-looking extinct animals found in no other continent, for South America was separated from North America for a long period and developed its own peculiar animals.

Elephant-like animals, called mastodons, recently discovered in southern Arizona, were mired in boggy mud holes adjoining springs. Some of their limb bones are found in erect position and the tops of the skulls are crushed in as though they were trampled on by other animals coming to the water holes. Cave deposits have yielded many interesting fossils. Some of these caves were the homes of beasts of prey and the fossils found there are their own remains and the remains of their victims. Other cave deposits are gashes into which animals fell and into which carcasses and bones of other animals were washed by rains. A crocodile, tapirs, peccaries, an antelope similar to the African eland and other animals that seem out of place in eastern United States were found in a cave near Cumberland, Maryland. Although fossils have been discovered in a few other caves in this country, no systematic attempt has been made here to ex-

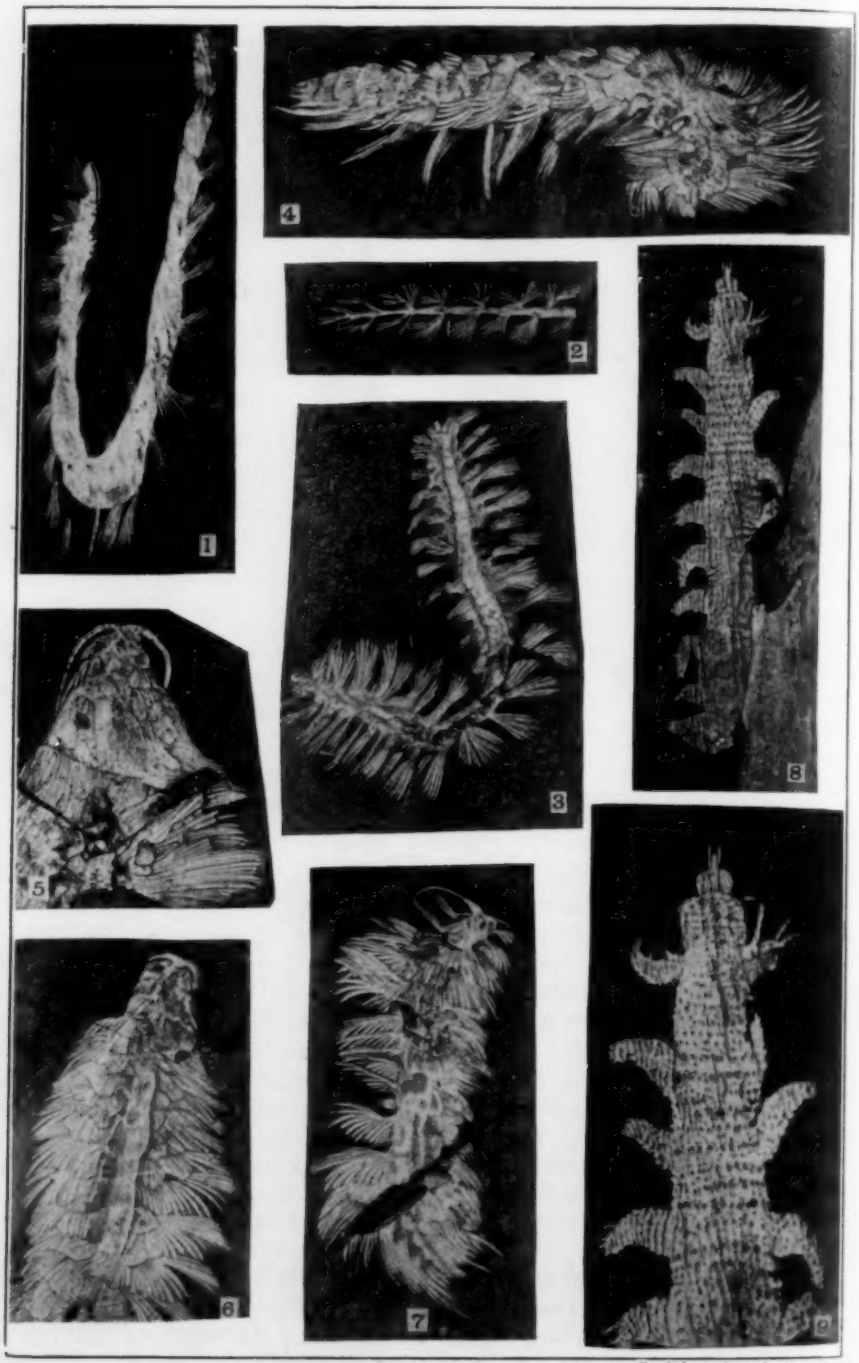
4 5

U. S. Geological Survey

FOSSIL PLANTS OF EOCENE AGE FROM TEXAS AND LOUISIANA

CANNA LEAVES.

plore caves for fossil animals. Rancho la Brea, within the city limits of Los Angeles, where asphalt has accumulated from escaping oil, is the most spectacular fossil locality in America. Here animals that lived during the Ice Age were trapped in the sticky asphalt. Animals that were caught served as bait for beasts and birds of prey and they in turn were trapped in great numbers. Water birds were caught along the edge of the pools of water that collected on the asphalt. More than sixty giant ground-sloths, two thousand saber-tooth tigers, three thousand giant wolves, to say nothing of short-faced bears, lions, camels, bisons, peccaries, horses, tapirs, mastodons, mammoths and many other animals and a great variety of birds have already been dug out of the asphalt. Despite the great number of animals trapped, complete skeletons with the bones in place are rare, principally because the bones were separated by movement of the plastic asphalt. At another famous locality in Bavaria fine muds, which now are quarried as lithographic stone, were laid down in lagoons behind reefs. These muds contain many remarkable fossils that lived long before modern animals appeared. Flying reptiles and the earliest known bird—a bird that had teeth and a backbone down its tail—fell in the mud and were covered by wind-blown dust. Impressions of the feathers of the bird are faithfully preserved. Sea animals were brought in alive when the lagoons were flooded and



Smithsonian Institution

MIDDLE CAMBRIAN WORMS FROM BRITISH COLUMBIA

ALTHOUGH THESE FOSSILS ARE MANY MILLIONS OF YEARS OLD, THE DETAILS OF THEIR STRUCTURE ARE FAITHFULLY PRESERVED IN THE FINE MUD IN WHICH THEY WERE BURIED.

signs of the death struggles of some of them can plainly be seen. Here and at many other places impressions of insects are preserved in fine mud, but the most complete fossil insects, as perfect as they were when they died, are found in the resinous gum of pine trees that has hardened to form amber.

Land plants are found in stream, lake, swamp and lagoon deposits. Leaves that fall in mud or sand leave imprints that become fossils if they are buried before they are destroyed. Such imprints are the most common plant fossils. In fine mud all the details are clearly shown. The plant tissue may disappear or it may remain as a film of carbon or as mineral matter that has taken its place. Tree trunks firmly rooted in the soil in which they grew have been uncovered. Wood that was buried and then petrified is common. Some of the most remarkable plant fossils found in America are fungi preserved in petrified wood. A locality in France is famous for leaves, fruits, seeds and flowers that fell in water rich in lime and were incrusted with lime.

When everything is considered it is remarkable that such a great variety of fossils has been dug up. All these remains represent animals and plants that happened to be buried before they completely decayed. Even then they would remain undiscovered unless they were brought to light in some natural or artifical excavation. Every year expeditions uncover and collect new material and the number of these animals and plants, some of which are grotesque beyond belief, is continually being added to.

ARE THE HEAVENS FULL OR ARE THEY VOID? A HISTORY OF HYPOTHESES

By Professor **FLORIAN CAJORI**
UNIVERSITY OF CALIFORNIA

I. Descartes' Theory of Vortices

Aristotle in his "Physics" and his book on the "Heavens" argued against the existence of a vacuum and filled the universe with a very thin hypothetical medium or plenum. After him, for nearly two thousand years, the universe was usually conceived to be a vast void. Then came the speculations of the great Frenchman, René Descartes. His mechanical hypothesis regarding the causes of the motions of heavenly bodies was advanced in 1644.[1] At that time the Copernican system was a century old. Kepler had established his three laws of planetary motion; Galileo had directed the telescope to the sun and seen sun spots, to the moon and had seen craters, to the planets and seen Saturn's ring "three-fold." A knowledge of *how* the heavenly bodies moved raised the question of *why* they moved. Galileo, in one of his Dialogues, lets Simplicio say, "The cause of this is most manifest; and every one knows that it is gravity." To which Salviati replies: "I do not question you about the name, but the essence of the thing, of which essence you know not a tittle . . ." Descartes' theory supplied a reason why, which captured the uncritical imagination of men of his time. Descartes made the sun the center of a great vortex or whirlpool of subtle transparent matter of interplanetary space, within which were smaller vortices. He compared his vortices with what one sees at a sharp turn of a river; the large vortex at the turn is accompanied by small eddies. The solar vortex carries the planets around, the inner parts of the vortex having a greater angular velocity than the outer, thus accounting for Saturn's thirty-year period of revolution to the earth's one-year period. The planets are the centers of smaller vortices; that of the earth carries the moon around in a little over twenty-seven days. Stars are constituted like the sun; each star is the center of a vortex. These stellar vortices fill all space; they touch each other. To avoid disastrous entanglements, contiguous vortices must rotate in opposite directions as would two rotating cylinders pressing against each other. That it is possible to fill space with such vortices, properly coordinating their movements to each other, Descartes did not show conclusively. His drawings of vortices do not clearly explain the behavior of the vortices in three dimensions.

This theory of vortices offers difficult mechanical problems with which the science of mechanics of that time was unable to cope. Only two of the three laws of motion were understood in 1644. Descartes' universe was constituted of three kinds of matter, the *luminous* matter of the sun and stars, the *transparent* matter of interplanetary space, and the *opaque* matter of the earth and planets. The transparent matter or the carrier of light is composed of globules whose sizes are intermediate between the vor-

[1] René Descartes, "Principia philosophiae," Amsterdam, 1644. See "Oeuvres de Descartes" edited by C. Adam et P. Tannery, Vol. 8, 1904. The translation into French of 1647 is in "Oeuvres," Vol. 9, 1904.

tex matter of the sun and the ponderable matter of the earth. These globules are constantly straining away from the center around which they turn, owing to the centrifugal force of the vortices, so that the globules are pressed in contact with each other. It is the transmission of this pressure which constitutes light. Colors depend upon the speed of rotation of these globules. Vision is due to pressure which we perceive in the same manner as a blind man perceives objects by the pressure these objects exert against his stick.

Descartes' exposition of his theories is very skilful. The arrangement of the subject is orderly; one topic is taken up at a time and made clear by an appeal to intuition and analogy. For example, sun-spots are made clear to every one by comparison with the froth which gathers upon the surface of boiling liquors. We are tempted to believe that Jules Verne, before writing his romances, took lessons in the art of exposition from Descartes. It would seem that Descartes aimed to leave as little as possible for his successors to do, for he worked out his theory of the universe in almost every detail. Thus he explained magnetism by assuming a vortex of fluid matter surrounding each magnet. Descartes' bold mind, following the method of philosophy, could travel immeasurably farther than the modern experimental scientist whose cautiousness and submissiveness border on servility, being willing to take only one or two short steps at a time, for fear that he might otherwise travel in a direction not sanctioned by the imperious decrees of experimental evidence.

II. Struggle between the Systems of Descartes and Newton

What reception was given to Descartes' vortices? Descartes became involved in controversies, but they did not concern his theory of vortices. That theory spread as rapidly as possible at that time. The original edition was written in Latin, which was the universal language of philosophy and theology. But through the efforts of a friend, a French translation, with additions by Descartes himself, appeared in 1647 and appealed to a wider circle of readers. Descartes died three years later (1650). Twenty-one years after his death, Descartes' vortex theory received a popular exposition in the famous text-book on physics, written in French by Rohault. A Swiss physician, Théophile Bonet, made a Latin translation of this text-book, which appeared at Geneva in 1674 and in London in 1682. Thus England began to use this popular text-book five years before the publication of Newton's "Principia." But long before this, Cartesian cosmology had invaded England. Henry More, of Christ's College, Cambridge, one of the first fellows of the Royal Society of London, in his earlier years, had been in correspondence with Descartes and was an admirer and supporter of Descartes. More's friend, Joseph Glanvill, of Exeter College, Oxford, also a fellow of the Royal Society, wrote appreciatively of Descartes' vortices. The writings of Robert Boyle teem with references to Descartes, "the most acute modern philosopher" whose "great wit" he greatly admired. But in Boyle there is only one reference that we could find, to the Cartesian theory of vortices, and that reference was "without allowing this hypothesis to be more than not very improbable."[2] Robert Hooke, of London, wrote in criticism of some features of the vortex theory.[3]

The struggle between Cartesian and Newtonian natural philosophy constitutes an interesting chapter. Descartes' vortices reached their greatest popularity about the time when the validity of

[2] "Works of the Honourable Robert Boyle," Vol. 5, London, 1772, p. 403.

[3] Robert Hooke, "Micrographia," London, 1665, pp. 60, 61.

the hypothesis was being undermined. The Cartesian doctrine had elements of popular strength. The non-mathematician could understand it, but could not understand Newton's system. The law of inverse squares meant nothing to one unaccustomed to mathematical thinking. Thus the Cartesian system enjoyed a tremendous advantage. On the other hand the British mathematicians, Halley, David and James Gregory, Keill, Whiston, Cotes, Taylor, Robert Smith and Saunderson favored Newton's doctrines. Newton himself lectured at Cambridge as late as 1699, but the details relating to his activity as a lecturer are extremely meager. After 1692 he had a long illness. In 1695 he was appointed warden of the mint. He was succeeded in the Lucasian Chair at Cambridge in 1693 by Whiston, who lectured on Newtonian philosophy. From these facts alone one might infer that Newton's system easily displaced Cartesianism in British universities. But such was not the case; the Cartesian system displayed wonderful vitality, even at Cambridge. For about forty years after the publication of Newton's "Principia" the French system maintained a foothold in England. We cite a few facts in support of this statement. The essayist, Joseph Addison, of Magdalen College, Oxford, delivered an oration in 1693, six years after the publication of Newton's "Principia," in which he praises Descartes, "who had bravely asserted the truth" against the followers of Aristotle.[4] Whiston[5] refers to David Gregory's teaching Newton at Edinburgh, "while we at Cambridge, poor wretches, were ignominiously studying the fictitious hypotheses of the Cartesian." We have already referred to the publication in England in 1682 of Rohault's physics, containing a popular exposition of Descartes' system. Fifteen years later, in 1697, a new translation of that book into Latin appeared from the pen of Samuel Clarke, of Caius College, Cambridge, whom Whewell describes as a "friend and disciple of Newton." While the translation was in progress, Whiston expressed himself to Clarke on the fitness of such a translation in the following terms:[6] "Since the youth of the university must have, at present, some System of Natural Philosophy for their studies and exercises; and since the true system of Sir Isaac Newton's was not yet made easy enough for the purpose, it was not improper, for their sakes, yet to translate and use the system of Rohault . . . but that as soon as Sir Isaac Newton's Philosophy came to be better known, that only ought to be taught, and the other dropped." It should be added that Rohault's was reputed to be by far the best treatise of that time on physics in general. Clarke's translation, in better Latinity, played an important rôle as a text-book, both in English and American colleges. John Playfair[7] says that this new and elegant translation contained additional notes, in which Clarke explained the views of Newton, so that the notes contained virtually a refutation of the text, avoiding, however, all appearance of controversy. Thus, continues Playfair, "the Newtonian Philosophy first entered the University of Cambridge, under the protection of the Cartesian." Playfair's statement needs emendation in one respect. Clarke's edition of Rohault, as printed in 1697, did not contain the additions as footnotes, but as annotations at the end of the volume, which are

[4] David Brewster's "Memoirs of Sir Isaac Newton," Vol. 1, 2. Ed., Edinburgh, 1860, pp. 291, 292.

[5] Whiston's "Memoirs of his own life," p. 36, quoted by Brewster, *op. cit.*, Vol. I, p. 291.

[6] Brewster, *op. cit.*, Vol. I, p. 295.

[7] John Playfair, "Dissertation Fourth" in Encyclopaedia Britannica, 8th Ed., Vol. 1, pp. 609, 610; quoted by Brewster, *op. cit.*, Vol. 1, pp. 290, 291.

shorter than in the later editions and refer to ancient writers, and *do not refute* Descartes' theory of vortices. Clarke's refutation came at a later date. Four editions of Clarke's Latin translation appeared. The third, issued in 1710, differs from the first in having the notes, not at the end of the volume, but at the bottom of the page as footnotes and greatly enlarged. This third edition (perhaps also the second of 1703, which we have not seen) contains a new annotation which relates to Descartes' vortices and points out conclusively that these vortices do not explain the facts of observation. They do not explain the motion of comets which cut the orbital planes of the planets at all angles; they would make a planet move fastest when furthest from the sun, while as a matter of fact it moves slowest when in that position.

On this subject, there is given a long quotation from Newton's "Principia." The popularity of Clarke's later editions of Rohault may be due largely to the footnotes. Taken as a whole, the text was acceptable to followers of Newton as well as to followers of Descartes. Both sides were fairly presented. Professor Playfair calls attention to the fact that the tutors in colleges, whose instructions "constitute the real and efficient system" in a British university, sometimes held different views from those of the professors. Thus Professor Keill introduced in his lectures Newtonian philosophy at Oxford, but the Oxford tutors "were not cast in that mold till long afterwards." Ball states that "at Cambridge until recently professors only rarely put themselves into contact with or adapted their lectures for the bulk of the students. . . . Accordingly if we desire to find to whom the spread of a general study of the Newtonian philosophy was immediately due, we must look not to Newton's lectures and writings, but among those proctors, moderators, or college tutors who had accepted his doctrines." Clarke's edition of Rohault suited therefore the needs of tutors, whichever of the two opposing scientific views they favored. That in 1723 Rohault's text was by no means discredited in England is evident from the appearance of an English translation of Clarke's edition, with the notes. Other editions of this appeared as late as 1729 and 1735. According to Hodlay's life of Samuel Clarke, Rohault was still the Cambridge text-book in 1730, three years after the death of Newton and forty-three years after the appearance of Newton's "Principia." It looks as if two different practices of instruction had been carried on for many years without open controversy between the two factions, one favoring Descartes as expounded by Rohault, the other favoring Newton as expounded in Clarke's footnotes, in Whiston's lectures published in 1710 and in the publications of Richard Laughton, a noted tutor at Clare Hall in Cambridge. Desaguliers,[8] who moved from Oxford to London in 1713, informs us that "he found the Newtonian philosophy generally received among persons of all ranks and professions, and even among the ladies by the help of experiments." Somewhat at variance with this is the statement of Voltaire,[9] who visited England in 1727, and declared that though Newton survived the publication of the "Principia" more than forty years, yet at the time of his death he had not above twenty followers in England. But Voltaire[10] said also: "A Frenchman who

[8] Jean T. Desaguliers, "Physico-Mechanical Lectures," London, 1717; quoted by W. Whewell, "History of the Inductive Sciences," Vol. 1, 3. Ed., New York, 1875, p. 426.

[9] F. M. A. Voltaire, quoted by Brewster, *op. cit.*, Vol. I, p. 290.

[10] F. M. A. Voltaire, "Elemens de la philosophie de Newton," 1738; "Oeuvres," Vol. 31, 1785, quoted by Whewell, *op. cit.*, Vol. I, 1875, p. 431.

arrives in London finds a great alteration in philosophy, as in other things. He left the world full, he finds it empty. At Paris you see the universe composed of vortices of subtle matter, in London we see nothing of the kind."

On the European continent, the vortices of Descartes enjoyed a longer life. Attempts were made by Huygens, Perrault, Johann II Bernoulli and others to remove some of the glaring defects of the original theory of vortices, but by the middle of the eighteenth century the Newtonian system had gained complete ascendancy.

III. The Eighteenth Century

The hold of Descartes' cosmology upon the minds of men in the early part of the eighteenth century is apparent from the fact that Roger Cotes wrote a long preface in the second edition of Newton's "Principia," 1713, in which he argues against Descartes' theory of vortices. The statement frequently made, that it was in this preface that Cotes advanced the theory of "action at a distance," needs qualification. Cotes does not use the phrase "action at a distance," nor does he explicitly advocate the view that celestial spaces are void. He does argue that if a celestial fluid exists it "has no vis inertiae, because it has no resisting force." The implicating sentences of his preface read as follows: "Those who would have the heavens filled with a fluid matter, but suppose it void of any vis inertiae, do indeed in words deny a vacuum, but allow it in fact. For since a fluid matter of that kind can no ways be distinguished from empty space, the dispute is now about names and not the nature of things." Perhaps Cotes avoided an explicit avowal of his belief in empty space, because of Sir Isaac Newton's firm belief in the existence of an ether. Samuel Clarke was more definite. In one of the footnotes to his later editions of Rohault he refers explicitly "to that immense Space which is void of all matter."

While Descartes had aimed to explain all celestial phenomena by one and the same theory, Robert Hooke and Christian Huygens confined their attention to the subject of light, postulated the existence of an ether and set up a wave-theory. Experiments indicated that light travels through a Torricellian vacuum and also through an air pump vacuum. Hence the ether must be present in these vacuums and must penetrate all matter. Newton postulated not only an ether, but also flying corpuscles.

It thus appears that in the seventeenth century, after the publication of Descartes' vortex-theory in 1644, the heavens were not a void but were full of some sort of a medium. At the beginning of the eighteenth century, Descartes' vortices began to be discredited. With the mass of thinkers, the elimination of Descartes' vortices left celestial spaces empty. We have seen that such emptiness was implied in the arguments of Cotes and was definitely asserted by Samuel Clarke. The ether of Hooke, Newton and Huygens was discarded. Individual thinkers of the eighteenth century, as Leonhard Euler, Benjamin Franklin and some others, continued their adherence to a universal ether, but to the great majority of scientists interplanetary spaces were void.

IV. The Nineteenth Century

At the opening of the nineteenth century, Thomas Young in England and Fresnel in France revived the wave-theory of light as offering superior explanations of reflection, refraction and interference phenomena. The wave-theory brought back the luminiferous ether, and the heavens were full once again. This theory was put to a severe

test to explain the polarization of light. Fresnel and also Young were driven to the assumption that light-waves have vibrations transverse to the direction of propagation, and this in turn necessitated an ether that was an elastic solid, for an elastic fluid like air would admit of only longitudinal vibrations. And if this ether is an elastic solid, how can the planets move through it without hindrance? Do the planets slacken in their revolutions? Many centuries of astronomical observation show no trace of such retardation. Fresnel concluded also that the ether possesses greater density in matter than in free space, and this density varies in different directions within a crystal. Part of this dense ether travels with the body, namely, that part that constitutes the excess of its density over the density of the ether in free space, and the remaining part of it is at rest. Fresnel and Young did not succeed in giving a rigorous dynamical theory of the ether.

Attempts at such a theory were made later by Navier, Cauchy, Neumann, MacCullagh, Stokes, Kelvin, Helmholtz, Larmor and others. How can the ether be a solid and yet permit the planets to move freely through it? Stokes and Kelvin pointed out that such substances as pitch and shoemaker's wax, though so rigid as to be capable of elastic vibration, are nevertheless sufficiently plastic to permit other bodies to pass slowly through them. In other words, the ether may behave like an elastic solid for very rapid vibrations, and yet yield like a fluid to the slow progressive motion of a planet. Does the planet carry the ether along with it, or is the ether undisturbed by the motion of the planet, or is there perhaps a partial drift of the ether? This question arises in the explanation of a phenomenon known as Bradley's aberration of light—the annual shifting of the direction, due to the motion of the earth, in which a star is seen. The principle of this shifting is familiar to us in rain falling vertically, which seems, when we run forwards, to be coming into our faces. Bradley himself found an easy explanation of this phenomenon on Newton's corpuscular theory of light, for the corpuscle acted similarly to the raindrop in our illustration. On the wave-theory, this aberration was difficult to explain. Young and Fresnel assumed for this purpose the ether undisturbed by planetary motion, like air quiescent to the motion through it of a swarm of bees. But if ether is not moved in the least by bodies passing through it, how can one explain the interaction between the ether and ordinary matter, as seen in everyday light phenomena? How can a light wave cause molecular motion called heat? In 1845, Stokes[11] replaced this "startling hypothesis" by the assumption that the ether close to the surface of the earth is completely dragged along by the earth, while higher up it is only partially dragged, and "at no great distance, it is at rest in space." On this supposition Stokes endeavors to explain Bradley's aberration and some other phenomena, but he was not altogether successful. An experiment which at the time was interpreted as confirming Stokes' assumption of an ether-drag was made by Fizeau. He sent rays of light in opposite directions through running water and obtained results which seemed to show that the water partially dragged the ether along in its course. More recently this same experiment received a wholly different interpretation by Einstein on his special theory of relativity.

A different movement was initiated by Clerk Maxwell. He was deeply impressed by the ideas of Faraday concerning electric action transmitted through a medium. On the belief in the simplicity of nature, Maxwell assumed

[11] G. G. Stokes, *Philosophical Magazine*, 3d Series, Vol. 27, 1845, pp. 9–15.

that the medium transmitting electric action was the same as the medium which transmitted light. The question arose—What are the properties of a medium transmitting electrodynamic effects?—and he found that such a medium would transmit waves with the velocity of light. Thus arose the electromagnetic theory of light. It was the era in England of model making. Distrusting mathematical symbols that had not a fully defined meaning, there arose a demand for a mechanical model exhibiting the stresses and strains bringing about the actions to be explained. But in recent years, this phase of his work has been pushed into the background. It is not Maxwell's effort along the line of model making, but his differential equations which are now proving to be of fundamental interest. As Jeans recently pointed out, Weyl generalized Einstein's theory of relativity so that it accounts not only for gravitational phenomena but also for electromagnetic phenomena, and arrived at equations which are identical with the electromagnetic equations of Maxwell. It appears that Maxwell's equations are capable of interpretation under various different conditions and therefore possess qualities almost magical. In the words of Goethe's Faust, it has been asked, "War es ein Gott, der diese Zeichen schrieb?" The great correlation which Maxwell's theory established between light and electromagnetism was attractive to many minds, but not to all. Lord Kelvin, for instance, was apathetic to Maxwell's theory. The mechanical properties of Maxwell's ether were not clearly defined; hence Kelvin clung to the elastically solid ether.

V. The Michelson and Morley Experiment

All in all a free ether which was not dragged along by moving bodies was preferred by physicists of that time. Certain phenomena remained unexplained by the free ether, but were not considered necessarily incompatible with it. The equanimity of physicists was rudely disturbed in 1887 when Michelson and Morley, at the Case School of Applied Science at Cleveland, Ohio, performed their famous experiment which, according to the old mode of interpretation, indicated that the earth drags the ether with it completely or almost completely; that is, the ether moves with the earth. The experiment caused consternation among physicists. Glazebrook[12] in 1896 exclaimed, "We are still waiting for a second Newton to give us a theory of the ether which shall include the facts of electricity and magnetism, luminous radiation, and it may be gravitation." Kelvin[13] in 1900 spoke of "two clouds" obscuring "the beauty and clearness of the dynamical theory which asserts light and heat to be two modes of motion." One of the clouds was the unexplained Michelson and Morley experiment.

Of the various suggested paths of escape from this difficulty, the one upon which special attention came to be directed was pointed out independently by G. F. Fitzgerald and H. Lorentz. Both made the assumption that a moving body contracts along the line of its motion. A yard stick is shorter when moving in the direction of its length than when it is at rest. On this assumption the Michelson and Morley experiment could be explained, even though the ether be taken to be stationary, not moving with the earth. The strangeness of this contraction hypothesis was partly removed by an explanation of it on the electric theory of matter. Lorentz went further and, on this hypothesis, deduced mathematically addition theorems for distances and for time, which deviate

[12] R. T. Glazebrook, "James Clerk Maxwell," New York, 1896, p. 221.

[13] Kelvin, *Philosophical Magazine*, 6th Series, Vol. 2, 1901, p. 12.

from Newtonian mechanics and are generally known as the "Lorentz transformations." He made a close approach to the modern theory of relativity. The announcement by Einstein of the special theory of relativity in 1905 and the general theory in 1915 are events in speculative physics which are even more spectacular than the experimental results of Michelson and Morley. Einstein built his theories without the use of the ether. He did not deny the existence of some kind of an ether, but for his immediate needs it was superfluous. In his little book entitled "Side Lights on Relativity," Einstein expresses explicitly his belief in an ether—not the ethers of the nineteenth century, not the ethers of Fresnel, Stokes, Kelvin and Maxwell; those he considers to be gone forever—but an ether which may be made to explain the kinks and twists in the neighborhood of gravitational masses. As yet this new ether of Einstein has not yielded such explanations. It is like Samson shorn of his locks. It is not playing a real rôle in physics. In fact, some devotees of relativity discard ether theories altogether.

V. Is the Special Relativity Theory Doomed?

For several years Einstein's relativity theory remained practically unchallenged by experimental scientists. All observations turned out according to its predictions. Astronomers observed that there was actually a bending of stellar rays of light which pass closely to the sun, just as Einstein had predicted. Relativity explained the peculiarities of the orbit of Mercury which had been mysterious on the old Newtonian mechanics. The shifting to the red of the spectral lines of light from the sun and from other heavy stars was predicted by Einstein and was verified in 1924 by St. John, of Mount Wilson, for sunlight, and in 1925 by W. S. Adams, of Mount Wilson, for light from a heavy star.[14] What was thought might be a crucial experiment between ether theories and the theory of relativity was suggested by Michelson[15] in 1904, and by Silberstein[16] in 1921. It contemplated the study of the effect of the earth's rotation on its axis upon the motion of light. It was actually performed by Michelson and Gale[17] at Clearing, Illinois, in 1925. Two rays of light were sent in opposite directions around a rectangle of water pipe over a mile long, from which the air had been partially exhausted. The two rays on returning to the starting point showed a displacement of a quarter of a wave length of the light used, an amount which can be explained on either of the two theories. If the two rays had matched exactly on returning, the Einstein theory would have been disproved, but not the ether theory. The experiment was not decisive between the two theories. The Fitzgerald contraction did not require consideration here, for the circuit of both rays was essentially the same. It is worthy of note that Michelson's experiment of 1925 indicates that the ether does not appreciably participate in the earth's motion of *rotation* about its axis, while his 1887 experiment indicated that the ether fully or almost fully participates in the earth's annual motion of *translation* around the sun. The two results are not considered necessarily in conflict. Silberstein[18] says: "If there is an almost complete translational (annual) drag of the ether due to its condensation around the planet, there may yet be no appreciable rotational (daily) drag."

[14] *Science*, Vol. 61, May 8, 1925, p. 10.

[15] A. A. Michelson, *Philosophical Magazine*, 6th Series, Vol. 8, 1904, p. 716.

[16] L. Silberstein, *Jour. of Optical Soc. of America*, Vol. 5, 1921, pp. 291–307.

[17] A. A. Michelson and H. G. Gale, *Nature*, Vol. 115, 1925, p. 566.

[18] L. Silberstein, *loc. cit.*, p. 307.

Thus relativity has emerged triumphant from four experimental observations which have been carried on with the greatest skill that instrumental science of the day affords. But we come now to a fifth test, which may be the undoing of Einstein's brilliant generalization. At the Case School of Applied Science and at Mount Wilson, Dayton C. Miller[19] has been making an extended series of experiments with instruments more delicate than those used by Michelson in 1887. According to Miller's announcement made at the meeting of the National Academy of Sciences at Washington on April 28, 1925, and at the Kansas City meeting of the American Association for the Advancement of Science on December 29, 1925, the general result of his observations performed on Mount Wilson gives a motion of the earth relative to the ether of ten kilometers a second, while in a basement at the Case School of Applied Science that motion was less than three and one half kilometers. In other words, the ether was dragged along with the earth to a lesser degree on a mountain top than underground near sea-level. This result is in contradiction with the special theory of relativity. That theory does not postulate the existence of an ether and appears unable to account for the difference in the phenomena of light propagation at low and high levels as exhibited in Miller's experiments. It should be noted that Miller's experiments at the Case School of Applied Science are not in conflict with Michelson and Morley's experiment of 1887, made at the same place. Michelson concluded that the relative motion of earth and ether is probably less than seven and one half kilometers per second, while Miller with more delicate equipment concluded, as already stated, that it was less than three and one half kilometers per second.

However, a bold challenge of Miller's results comes from Eddington,[20] of Cambridge, England. He claims that Miller's results are in conflict with astronomical observations on the positions of stars, extending over centuries, and far more delicate than Miller's experiments can possibly be. Eddington argues that if the ether were dragged along more completely at sea-level than at a mountain top, then this ether would exhibit rotary motion resembling eddies in water that is traversed by a boat and that a ray of light passing through this turbulent ether would be bent in its course. In consequence there would be a difference of as much as seven seconds of arc in the position of a star when sighted at sea-level and when sighted at a mountain top. But no such difference has been observed. It will be interesting to watch the outcome of this conflict. In presenting his argument, Eddington assumes an ether endowed with certain properties. Is it possible that the experimental results are all correct and that it will be only necessary to reconstruct our theories of the ether? Is it possible to reconcile Miller's data with astronomical data by an ether constructed with properties somewhat like those given it by Stokes,[21] Planck, Lorentz or Silberstein?

Very recently a second challenge of Miller's results has come from a physicist, Rudolph Tomaschek, of Heidelberg, who performed two experiments designed to test the ether drift.[22] Both failed to yield evidence for the motion of

[19] Dayton C. Miller, *Science*, Vol. 61, June 19, 1925, pp. 617–621; *Proceedings National Academy of Sciences*, Vol. 11, 1925, pp. 306–314.

[20] A. S. Eddington, *Nature*, Vol. 115, 1925, p. 870.

[21] G. G. Stokes, *Philosophical Magazine*, 3d Series, Vol. 27, 1845, pp. 9–15; L. Silberstein, *Philosophical Magazine*, 6th Series, Vol. 39, 1920, pp. 161–170.

[22] *Annalen der Physik*, 4. S., Vol. 78, p. 743–756.

the earth through the ether. The nature of his two experiments is wholly different from Miller's. He uses condensers. In one experiment Tomaschek employs a charged electric condenser which, if moving through the ether, should produce a magnetic field, but none was observed, even when the test was made on the Jungfrau, one of the highest peaks in the Alps.

VII. The Present an Age of Bewilderment

Are the heavens full or are they void? We answer that we do not yet know. There are those who hold that celestial spaces are filled, not by an ether, but by flying particles of light.[23] The theory of relativity rejects all nineteenth century ethers, and some of its adherents consider celestial spaces void. On the other hand, the theory of relativity itself confronts some ugly facts in D. C. Miller's experiments. But the latter have been declared to be in sharp conflict with well-established astronomical measurements on the positions of stars. Miller's experiments at Cleveland accord fairly well with Michelson and Morley's experiment of 1887 at that same place. But this 1887 experiment, indicating that the ether moves with the earth in its annual path around the sun, is difficult to reconcile with Michelson and Gale's experiment of 1925, indicating that in the rotation of the earth on its axis the ether is not dragged around. Those who discard the ether must discard with it the wave-theory of light which has offered very easy explanations of the optical properties of light, while those who reject the corpuscular theory find it hard to interpret some of the electrical properties of light. Possibly a combination of the two theories will be helpful, as suggested by Sir Joseph Thomson.

Looking backward and passing events in rapid review, we see the heavens as full in the writings of Aristotle. Nearly two thousand years later, they were filled again by Descartes and in a different manner by Hooke, Newton and Huygens. Then they were declared empty by Cotes, Samuel Clarke and most European scientists, only to be filled again, during the nineteenth century, by Young, Fresnel, Faraday, Stokes, Kelvin, Maxwell, Helmholtz and others. Then came the champions of relativity, who either assign the ether a very secondary place in their speculations or discard it entirely. But now they are themselves hard pressed in defense of their famous theory.

What about the various hypotheses? Were they worth while? We answer most positively, *Yes*. They have not led to ultimate general truths, but they have been the means of accumulating a large amount of experimental knowledge which is of value to the material, intellectual and spiritual life of mankind. Scientists have travelled far and seen much. Yet they evidently are on the verge of seeing new sights which equal or surpass anything of the past. They are like the explorers on their first view of the vastness of the Pacific Ocean, who, in the words of Keats,

> Looked at each other with a wild surmise—
> Silent, upon a peak in Darien.

[23] See C. Benedicks, "Space and Time," London, 1924, p. xiv.

THE RELATION BETWEEN CULTIVATED AREA AND POPULATION[1]

By SIR DANIEL HALL, K.C.B., LL.D., F.R.S.

RECENT considerations of the problem of the capacity of the world to continue to feed its growing population appear to have begun with the late Sir William Crookes' address as president of this association when he discussed the ultimate curtailment of the wheat supply through exhaustion of the soil nitrogen. Crookes's views attracted little more than academic attention at the time (1898) because the great tide of wheat that was setting in from the newer countries still in the process of exploitation was barely slackening; moreover, Crookes had neglected a factor then imperfectly appreciated—the fact that land under any of the conservative systems of farming adopted in the old settled countries does not become exhausted. The recuperative effects of the leguminous crops and the assimilation of nitrogen by soil bacteria like azotobacter have maintained unimpaired the fertility of European soils for perhaps thirty centuries of cultivation. Of course, reckless exploitation, such as the continuous growth of wheat and maize without any manuring, will eventually burn out the resources of even the prairie soils of the Middle West, and there is evidence that some of the long cultivated Indian soils are losing fertility if only because dung and other residues which should go back to the soil are being burnt as fuel or sold away; but generally speaking a soil will maintain itself indefinitely at a certain level of production. Latterly in Europe that level has been raised by the introduction of extraneous fertilizers.

[1] Address of the president of the section of agriculture of the British Association for the Advancement of Science, Oxford, August, 1923.

In his review Crookes predicted the development of the synthetic processes of bringing nitrogen into combination which are to-day rendering that prime element of fertility so abundant and so cheap. But, though we no longer fear the exhaustion of soils, of late years certain sociological considerations have revived interest in the old thesis of Malthus. Over-population and unemployment have become terrible realities in this and other countries; many states are finding themselves under pressure to maintain their standard of living against the intrusion of neighboring races propagating recklessly down to the barest margin of sustenance. Again, various studies of the course of prices of wheat have led to the conclusion that before the war the real price was rising continuously, and that this tendency is manifesting itself again, however much the true sequence of prices has latterly been obscured by fluctuations of currency. These considerations led Mr. Keynes to envisage the approach of scarcity: his attitude is very much a return to Malthus. On the other hand, Sir William Beveridge, addressing the economics section two years ago, dismisses this fear as regards the world at large, whatever may be the troubles in Britain, "the limits of agricultural expansion are indefinitely far." On the whole that seems a very safe proposition; it has been so amply fulfilled for the last hundred and fifty years—during the greatest expansion of population the world has ever known, that it would almost seem to be necessarily true, especially as it can be buttressed by agricultural experiments showing the enormous

potentialities of production from the soil.

There is, however, one aspect of the case that appears to have received insufficient attention: the capacity of agriculture to provide food for the people depends upon the extent of land available as well as upon the pitch of cultivation—to what degree can the tuning-up of methods be made to compensate for a non-expanding acreage? The first step towards a more exact consideration of the problem may therefore be an estimate of the amount of cultivated land that is required to maintain one unit of population—man, woman and child.

We may make our estimates by either of two methods—abstract or actual. The Food (War) Committee of the Royal Society adopted the figure of 2,618 calories as representing the minimal daily energy requirement of one unit of the population, and calculated that the actual United Kingdom consumption in the five years 1909–1913 amounted to 3,091 calories per head per day. An average English acre of wheat yielding 32 bushels will produce food in the shape of wheat, flour, and pig obtained from the offals, of a calorie value of about 2½ millions. As the average consumption was about 1.13 million calories per head per year, we arrive at the conclusion that one acre of wheat would support more than two head, the relationship being more exactly 0.45 acre to feed one unit of population. But this figure is of no service in our more general consideration. The yield of wheat of 32 bushels per acre is far above that of the wheat-producing areas, and is that of only a few selected countries growing but a limited acreage. It is again the produce of land under the plough, and is consumed in the main as a vegetable product.

The great areas of grassland have a lower output of energy than the cultivated land, and the conversion of vegetable into animal food, whether of natural or cultivated fodder crops, is always attended by a great waste of energy. In the most economic production of pig-meat or milk the energy recovered is only about one sixth of that consumed, and this represents the machine at the top of its efficiency. The longer period of beef production results in a recovery as beef of only one eighteenth of the energy consumed, and in practice the actual wastage of fodder and feeding stuffs doubles or trebles the inevitable losses by conversion. And just as man is not a vegetarian making the most of the mere sustaining power of the land, so he does not use the land for food alone, but also for drink, for wool and fibre and other industrial materials, and for amenities. You may remember Maitland's argument that in the early medieval times of Domesday Book and the two or three centuries following about one third of the arable land of the country was devoted to beer.

We shall not get far on the theoretical basis, and I have only mentioned it as indicating the order of the superior limit of the maintaining power of land.

We must approach the question in a more empirical fashion and endeavor to ascertain the existing relation between the land in use and the people fed by it. Taking again the estimates of the Royal Society's Committee, it concluded that the United Kingdom production of food for the five pre-war years was 42 per cent. of the food consumed. 46.7 million acres of cultivated land then produced 42 per cent. of the food consumed by a mean population of 45.2 millions, which works out to 2.5 acres to each unit of the population. This figure, however, is somewhat misleading in that it does not do justice to British agriculture, since our farming is to a considerable degree concentrated on the more costly elements of diet like meat or milk rather than upon cereals and sugar. For example, 49 per cent. of the food production at home, as against only 24 per cent. of the imported food, consisted of animal products.

Working on a different basis, Sir Thomas Middleton estimated that 100 acres of British land fed forty-five to fifty persons, so that his estimate is over 2 but less than 2½ acres for the maintenance of the unit of population. Middleton proceeds to estimate that 100 acres in Germany fed seventy to seventy-five persons, or 1.3 to 1.5 acres per unit, the advantage being due on the one hand to a much higher proportion of arable land in Germany, and on the other to a dietary in which the energy was obtained more economically, *i.e.*, from potatoes compared with meat, and in meat from pork rather than from beef.

The importance of this relation between cultivated area and population is so great, and the calculations by which it can be ascertained are so approximate and subject to so many estimates of a speculative kind, that I may be allowed to set out various results obtained by different methods.

We may begin by comparing population and area of cultivated land for all European countries except Russia, to which we add the United States, Canada, Argentine, Australia and New Zealand, as the white countries which are also the chief exporters of food to Europe. I exclude all oriental countries because in them the mass of the population possesses a different standard of living, and I have excluded the other South American States and the Union of South Africa and other African colonies because they all possess a very large "native" population and their exports do not bulk large in the food account of Europe. We must recognize, however, that the errors in the calculation will be loaded on to one side, because all the unenumerated countries, Russia and the tropical lands, are to a greater or less degree exporters and not importers of food. Sugar from the East and West Indies, rice and similar Oriental cereals, copra and other edible oils for margarine, are but a few of the agricultural products which the white population consumes from land outside our immediate purview. However, with this proviso we find that in the states enumerated there are 464.1 million hectares of land under cultivation and a population of 481.5 million persons, or 2.4 acres per head.

In the United States about 356 million acres are in cultivation: from this may be deducted as producing exported materials, for cotton 24, for wheat 16, for maize 2, for meat products 22 million acres, or 65 million acres in all. Other products are exported but may be regarded as balanced by imports, so that we find 291 million acres of cultivated land devoted to supplying a population of approximately 112 millions, or 2.6 acres per unit of population.

France we know is a country that is largely self-supporting; it has a population of 39.3 millions and 36.3 million hectares under cultivation. To this acreage we must add 0.9 million for imported wheat, 0.5 for other cereals, and 1.1 for imported meat; the exports of wine and fruit we may regard as balanced off by other imports. The net result is approximately 1 hectare, or 2.4 acres, for each head of the population.

A similar calculation applied to Spain, a country in whose economy neither exports nor imports of food play a large part, gives over 4 cultivated acres per unit of population; but then the so-called "cultivated" land includes a considerable proportion of mountain pasture of a very low order of productivity. On the other hand, Denmark, with the most highly developed agriculture of all countries, shows a production well above the average. A much closer calculation of production is possible for Denmark than for other countries—the data are set out in Mr. Harald Faber's paper before the Statistical Society in 1924. Denmark is a country exporting agricultural produce chiefly in its most costly form as meat, butter and eggs, but the means for equating the export against consumption is supplied in Mr. Faber's paper by the

reduction of production and imports to food units. Making the necessary corrections for imports, it would appear that for the years 1909 to 1913 the population of Denmark was maintained on 63 per cent. of the production of her own land or 1.82 acres per person.

Putting the various estimates together we arrive at the conclusion that under the existing conditions of agriculture among the Western peoples it requires something between 2 and 2½ acres of cultivated land to supply the needs of one unit of population living on the standard of white peoples.

We may confirm this estimate by a consideration of the growth of population during the last century. Between 1800 and 1920 the number of the white peoples increased from about 200 millions to about 700 millions. Data, however, for the land under cultivation in 1920 are very imperfect, and again there was another factor of improved agriculture which came into play in the first half of the nineteenth century. If we take 1870 as our jumping-off point we may estimate the increase in the white man's numbers up to 1920 as approximately 225 millions. During the same period the addition to the cultivated lands in Europe, United States, Canada, Argentine, Australasia, and South Africa, the countries which have provided the white races with food, has amounted to about 450 million acres. Again we reach a relation between cultivated land and population of between 2 and 2½ acres per head.

This brings me to the central point of my argument that an increase of population is in the first instance dependent upon an increase in the area of cultivated land. The expansion of the white peoples in the last century was an event unprecedented in the world's history, and was achieved only because of the vast areas of unoccupied land chiefly in the Americas which suddenly became available for settlement through the power conferred by the railroad, the steamship, and modern weapons. It will be noticed that the population of Europe previously had become comparatively stable even as it has become approximately stabilized in France at present—the expansion came with the opening up of the new lands and in proportion to the amount that could be settled.

Accepting as a basis for further discussion that under the present system of agriculture something more than two acres of new land will have to be brought under cultivation for each unit of increase in the population, we may examine if any means exist of modifying this relationship before considering its consequences.

I have already suggested that a vegetarian diet is the more economical of the resources of the soil, and that meat and all animal products like milk and eggs are produced with an expenditure of energy which may be as low as seven but also as high as twenty times the energy available from them. It is true that to a certain extent the animal will utilize material otherwise of little service to man, like milling offals and low-grade fodder crops—roots, hay, or straw. None the less, if the maximum of population supported by a given area of land is the objective, vegetarianism becomes increasingly necessary, as we see among the crowded populations of India and China. At the same time, the tillage of lands now given up to the grazing of animals becomes possible because of cheapness of labor resulting from a redundant population. Most of the beef and mutton supply comes from land left untilled because of the costliness of labor relative to products; the meat may represent a very low level of production from the land and yet a high cash return for the labor expended. Here the apparent paradox of grazing being general in Middlesex because of the proximity of London. Another item of waste which would have to be eliminated in case of stern necessity is the conversion of potential food into alcoholic drink. Great

Britain ferments the equivalent of one and a half million acres of barley. France devotes 4,000,000 acres, nearly 4½ per cent. of her cultivated area, to vineyards. Without going so far as to say that beer or wine possesses no food value, it is certainly not half of that which could have been grown from the land thus used for the production of drink. In such matters it is vain to prophesy, but I can not help feeling that the race (not individuals) which cuts out meat and alcohol in order to multiply is of the permanent slave type destined to function like worker bees in the ultimate community.

The second question that merits very careful consideration is whether the current agriculture can not be intensified so as to bring about a great increase of production from the existing area of cultivated land. A cursory examination of the average yields of our chief crops in different countries shows what an immense potential increase of production is here open. The average yield of wheat (1921 to 1924) for all the countries of the world collecting statistics was 13.2 bushels per acre; the average yield in Denmark for the same period was 41.4 bushels per acre, more than three times as much. Of course the area devoted to wheat in Denmark is about 200,000 acres in all, or 3 per cent. of her arable land, whereas the wheat acreage of the world amounts to about 250 million acres. The mass production of wheat in the world is from countries of low yield; more than half is grown in countries in which the average yield is less than 13 bushels per acre.

It is from these countries with the low yield per acre that wheat is exported and their production determines the world market, with the consequence that wheat production has been increasing in these and similar countries while it has been shrinking in the European countries with a higher yield per acre.

The dominating factor has been cost of labor; speaking broadly, it may be said that increased yields per acre are associated with higher expenditure per bushel for labor, and the great wheat-producing countries with a low yield per acre are the countries with a correspondingly high yield per man employed. It may be estimated that in England a man's labor produces about 960 bushels of wheat, in Australia 1,500 bushels. A more exact comparison shows that in England the labor cost amounts to 1*s.* per bushel of wheat, against 8*d.* in Canada, this with an average wage rate of 30*s.* to 36*s.* a week in England as compared with 60*s.* in Canada.

1924	Total production million quintals	Quintals per hectare	Bushels per acre
Russia	90	5.4	7.9
Canada	71	8.0	11.4
United States	238	10.8	15.5
India	99	7.8	11.1
Argentina	52	7.2	10.3
Australia	44	10.0	14.3
	594 (mean)	9.09	13.0

Recorded total, 932 (estimated for all countries, 1,250).

All this goes to show that intensification is only to be purchased at the cost of labor and that in the past extending the cultivated area has been a cheaper way of getting the wheat required by the world than by higher farming.

This general statement, however, does not tell the whole story; particularly it disguises the intensification of yield that may be obtained without a commensurate increase of labor. For example, the introduction of more heavily cropping varieties, originated by the skill of the plant breeder, may add greatly to the production from a given area without increasing costs other than those of harvesting and marketing.

One must not, however, expect too much of the plant breeder. Over the

greater part of the cultivated land of the world the gross amount of production is limited by external factors such as water supply, temperature, available fertility of the soil, etc. For example, the plant breeder seems to have had little or no power to increase the absolute production of *Beta vulgaris*; from all the forms of sugar beet or fodder beet (mangolds) on a given soil there is much the same yield of dry matter per acre, though in the well-bred sugar beets the proportion that is in the useful form of sugar is greatly enhanced. The wheats and barleys grown in England had long been subjected to selection and improvement before the scientific methods of plant breeding were evolved, and the further steps in improvement are going to be neither big nor easily won, depending as they do upon altering what Dr. Beaven has called the migration ratio, whereby the plant will convert more of the material obtained from the air into useful grain and leave less as straw. The chief opportunities, in fact, lie in the elimination of susceptibility to disease or destruction by frost, or general tenderness of constitution, by which means the range of the high-yielding cereals or even of cereal growth at all may be enormously extended. Absolute yielding power is perhaps less in question than productive capacity in relation to the environment.

The general enhancement of production by processes which induce improvements of the water supply or the temperature, as by irrigation and drainage, soil amelioration, cultivations, etc., suffer from the disadvantage of calling for labor, until they may prove far more costly than the increased produce can repay. Fertilizers appear to offer more promise. It may be recalled that the general level of production from English land was raised by nearly 50 per cent. between 1840 and 1870. At the beginning of the period the average yield of wheat was of the order of 20 bushels per acre, this being the crop the land was capable of maintaining under a conservative rotation with no extraneous source of fertility. But between 1840 and 1870 artificial fertilizers were introduced and became a generally accepted part of British farming, with the result that the yield of wheat had risen to about 30 bushels per acre, though no other marked change in the routine of cultivation had been adopted during the period. The employment of fertilizers still lags far behind the opportunities of employing them to profit; from 1870 onwards came the great depression upon British agriculture consequent on the growing irruption of the cheaply grown American corn and meat. British agriculture had to shorten sail and restrict expenditure; falling prices breed lack of confidence and even lack of knowledge, for why should a farmer study a science that calls for expenditure when the safer procedure is to let the land grow a small crop without cost rather than to buy a big crop at a dangerous price? At any rate, our employment of fertilizers continues to be unnecessarily low even under later conditions of prices, and the revolution that is being brought about in the production of nitrogenous fertilizers finds our farmers comparatively disinclined to take advantage of it. The various processes of bringing atmospheric nitrogen into combination to which the war gave such a stimulus are now being developed on a vast scale in all civilized countries, and will result in an almost unlimited increase in the amount of nitrogenous fertilizer available at low prices compared with the prices of agricultural produce. Here at least is the opportunity for another step up in production from our cultivated lands comparable with the progress that was made between 1840 and 1870. It is not all plain sailing; the farmer has to study carefully where an increased supply of the cheapened nitrogen can be most suitably applied to his land and what changes in his system of cropping are demanded. The plant-breeders' art is

needed; on most of our land any great enhancement of growth of cereals brought about by the use of nitrogenous fertilizers is attended with the danger of lodging. Few of our cereals possess stiff enough straw to remain standing on a soil enriched to the degree even that is reasonably practicable to-day. Thus the more immediate outlet for the new fertilizers would appear to be the fodder crops which are convertible into meat and milk.

But in the solution of the main problem under discussion—the possibility of intensification of production from the existing farmed land to meet the needs of a growing population—the development of the synthetic nitrogen fertilizers must play a dominant part. Crookes's prophecy is coming true.

I have reserved until the end the question of whether the intensification is necessary or probable. From previous experience it would appear to be probable that as long as new land is available the increase in food supplies will be won less by increased skill and expenditure applied to existing land than by taking in new land. The recent history of United States land affords an illustration; we see little improvement in farming or increase of yield on the older land —we see even abandonment of farms in the eastern states; at the same time we see continued attempts to win new land by forcing into cultivation the arid lands and alkali soils which the earlier settlers had rejected. All over the world it always astonishes the traveller to see on what bad lands the new settler is now trying to farm. Evidently the good easy virgin land is no longer easy to find. It is indeed significant that in the United States vast irrigation schemes are being carried out, though they show little signs of paying interest on their construction; that in Canada new wheats are being acclaimed because they may extend settlement into regions where killing frosts may be expected in August; that "dry farming," with a crop in alternate years only, has to be resorted to in Australia and South Africa. These facts would seem to show that land is getting short in the world, at any rate the naturally productive land or to which the great expansion of the nineteenth century proceeded. Where are we to find the 500 million acres of land such as was added to the world's farm between 1850 and 1900?

In Europe there are still great areas of forest, swamp and heath that might be brought into cultivation, but the process would involve an expenditure both of initial capital and continuing labor out of proportion to the returns. Either the prices to be received for produce must rise greatly or the cultivators must be content with a much lower standard of remuneration before there is much addition to the European area under cultivation. In fact, the present tendency is in the other direction—only Italy, with its great pressure of population increase, is adding to its farming land and reclaiming wastes. All over the poorer land of Great Britain abandoned holdings and crofts may be traced, abandoned for economic reasons alone, because men would no longer live and work so near to the starvation level. Nothing but the direst need or a new scale of prices, whereby agriculture becomes relatively the most paying industry, will ever bring such land back into cultivation. Other European countries to a less degree show the same tendency at work. Russia was one of the granaries of Europe, but over a large proportion of that vast territory production is precarious because of drought on the one hand and cold on the other. It may be doubted whether there will be any great surplus for export even when its agriculture has been fully resumed, so rapid had been the growth of its population to a magnitude which makes the losses of the last decade insignificant.

In the United States there are still great areas of potential farming land; for example, O. C. Baker ("Economic

Geography," 1925) estimates a possible increase of the wheat area in the U. S. A. from the present 80,000 to 130,000 square miles. But little of this, however, is the natural easily farmed land the settler looks for; the drift of late years of American farmers to Canada, the efforts to make good the arid lands by dry farming and irrigation, show that the good land has mostly been taken up. What remains is land on which capital outlay is required, land on which production will always be more costly than on the great fertile plains of the Middle West. As in Great Britain, the recent tendency in the United States has been to abandon the cultivation of some of the poorer lands and let them fall back to grazing. Canada still presents enormous potentialities for settlement, though the vast areas the map reveals are severely restricted by increasing aridity towards the west and by cold northwards; Baker considers an increase of the wheat area from 25,000 to 120,000 square miles as physically possible. But similarly on most of this land the wheat will have to be more dearly bought by labor, fertilizers and skill than on the land now being farmed.

The potentialities of South America are less easy of estimate, but in this region there is still a great area of rich plain country unsettled, and it is not too much to expect that another 40 million acres of land are available for farming under present conditions.

The potentialities of non-tropical Africa and of Australia are small; in the latter country the arid zone lies so near to the coast that the additional area available for normal cultivation is negligible in considering the world's need of food. The great unknown factor in this survey is Western Siberia, a natural wheat area, and Manchuria. All that can be said is that the physical possibilities are great, perhaps as high as 300 million acres, but no one can guess when that will be realizable, dependent as it is upon the establishment of a stable and ordered government. Moreover, on the flank of these regions hang the vast unsatisfied populations of China and Japan, ever ready to expand as the means of sustenance permits, and on this account the expectation of food for the Western peoples from this area can be but small. It is noteworthy that the far Eastern countries, so far from contributing to the food supply of the European peoples, have themselves of late years become competitors for wheat in the world market to an extent that has had a decisive effect upon prices.

As potential sources of food there still remain the tropical countries, in particular Brazil and Central Africa, where abundant rainfalls and high temperatures render feasible a very high level of production from the soil. The last fifty years has witnessed remarkable examples of organized production of tropical crops under western direction and management. The growth of sugar in Java, Cuba, and Hawaii, of rubber in Ceylon and the Straits, of tea in Ceylon and Assam, afford examples of the possibilities of organized agriculture, employing the resources of science, the labor-saving power of machinery, the criticism of cost bookkeeping, such as can rarely be paralleled in the farming proper of the temperate regions. The same organization is being extended to the coconut, which as margarine is becoming one of the chief edible fats of the world. Without doubt the tropics present enormous potentialities of food production for the world, mainly in the direction of oil seeds and edible beans. It must, however, long remain uncertain to what extent the cheap native labor upon which these tropical exploitations are dependent will continue to be available. It does not appear to be possible to maintain a white population itself engaged in the cultivation of the soil in contact with native labor, and Queensland is the only tropical country where agricultural development is being attempted with white labor only. The les-

son of South Africa and to some extent of the southern states of the U. S. A. would seem to be that the white races can not expand agriculturally in competition with the black.

The present annual increment in the white population may be estimated at about five millions. This, taken alone, would necessitate the taking into cultivation of twelve million acres of new land every year. No process of the kind is going on; indeed, for many crops there has been an actual shrinkage in the acreage since the war. Full records are not available, but the following table shows the changes in the areas of some of the main crops:

CHANGES IN AREA UNDER CROP. MILLION HECTARES

	1909–13	1921	1922	1923	1924
Wheat	107.8	103.5	99.5	104.0	105.6
Rye	44.3	37.0	40.7	44.6	43.9
Barley	33.3	29.4	27.3	30.9	30.7
Oats	57.4	55.1	50.7	53.8	55.8
Maize	70.6	71.7	73.0	74.1	(75)
Rice	47.8	53.0	53.3	51.8	52.8
Potatoes	15.3	14.8	15.3	16.2	16.6
Sugar Beet	2.3	1.7	1.7	2.0	2.6
	378.8	366.2	361.5	377.4	383.0

The shrinkage is doubtless no more than a temporary matter, the backwater of the wild fluctuations of prices and values brought about by the war, but it does not promise well for that continued expansion of the cultivated area which the still growing population demands. Indeed, we may detect a new influence at work, the growing disinclination of the civilized peoples to continue in agriculture because of its small and uncertain returns as compared with other occupations. It appears to be a general experience that wherever by the extension of communications the industries or commerce come close to agriculture the latter declines and begins to lose its best brains, its capital, and its men. The lure of the cities is proverbial, but the fundamental factor is economic; unorganized agriculture can not pay the wages obtainable in the organized industries. The decline in the agricultural population of Great Britain and the United States is the most marked, but it is significant that in France, where of all countries the farmer is most protected and prices have been maintained, the peasants are leaving the land for the growing industries, their places being taken, in the south at least, by Italian immigrants.

The flight from the land is manifest equally among the wage-earners of large-scale agriculture and among the peasants or family farmers in whose hands resides the greater part of the cultivation, whether in the old settled countries of Europe or the newer exploitations of America. Again and again it must be urged that the determining cause is economic; for the last half century, save for the abnormal war years, farming has not paid a return on the capital and labor expended comparable with that obtainable elsewhere. It has been said that even the American farmers of the Middle West, who cut prices for all the world, made no profits during the last half-century except those derived from the accretion of land values. And the peasant farmer, who counts neither the capital he has in the business nor the hours of labor he gives to his land, who in Europe is held to the land by secular tradition, finds agriculture unattractive as soon as the growth of industries and the spread of communications render an escape possible. If not the peasant himself, at least the sons look for an easier and less exacting mode of life.

At this stage it would be impossible to begin to diagnose the causes of the comparative unprofitableness of agriculture. Fundamentally it is due to the weakness of the farmer as a commercial unit; the smaller the farmer the more ruthlessly does he compete with his neighbors and reduce prices to a bare level of sustenance for his long hours of labor. Even the large farmers who can put into prac-

tice some of the economies of an ordered industry are helpless against the large commercial organizations which pass on their produce to the customers. Always there is the peasant farmer to cut prices. The position of the imperfectly industrialized farms may be compared with that of the new factories a century ago: their processes are not sufficiently developed to enable them to compete with any certainty of success against the single-handed worker, the power mill has not yet beaten the hand loom.

I can not, however, pursue this issue. I return to my original text, that if we are to continue to feed the growing population of the world on the present methods a continued expansion of the cultivated area is required; new land is called for year after year. I can not see where this new land of the necessary quality is to be found in quantities commensurate with the immediate demand. Doubtless the white races will insist on maintaining their rising standard of living and will apply deliberate checks to their fertility, a process we already see in action. But the restriction of increase will not take effect all at once even under economic pressure, and the danger lies in the period preceding the comparative stabilization. As it can not be supposed that the development of the civilized races can be allowed permanently to be checked by lack of food when food is obtainable, it follows that resort must be had to the intensification of production from the area already under cultivation. The means for that intensification are already in sight, more will be supplied with the advancement of research. Intensification, however, is in the main attended by a higher cost of production, and movement in that direction is likely to be slow until it is stimulated by a rise of prices. Organization will have to be introduced into the industry, and it may be expected that organization will take one or other of three forms. The farmer may be left as the producing unit, but his methods will be strictly controlled and standardized by the great selling corporations that handle his produce, and these corporations may be either commercial ventures or cooperative associations of the farmers themselves. The cooperative venture appears to imply an even more rigid discipline of the individual than that imposed by the capitalist firm. Alternatively the capitalist may venture upon the direct exploitation of large areas of land and industrialize farming as he has industrialized other producing businesses. But capital will only be tempted back to farming, whether for the organization of the business or even to enable the individual to take advantage of the possibilities of intensification, if prices rise to a definitely remunerative level. I hope I have given reasons for supposing that they must rise, because the surge in population set up by the unprecedented extension of the cultivated area last century can not all at once be checked, whereas the new land still available is either inadequate in amount or unsuited to cheap production by the old methods. How close at hand the period of pressure may be it is unsafe to prophesy, but it may be agreed that pressure is sooner or later inevitable and that one of the biggest problems before the world at present is to prevent the pressure developing suddenly or becoming unbearable. The intensification of production is the only remedy, and again the only means of rendering intensification practicable is the continued pursuit of scientific research.

POWER RESOURCES OF THE UNITED STATES

By HARRISON D. PANTON

RALEIGH, N. C.

In past generations the degree of military power possessed by a nation was the criterion of its greatness. To-day the possession of economic resources and the ability to exploit them has assumed an equal importance in determining a nation's standing as a world influence. The most essential factor in such economic exploitation of natural resources is mechanical power, the substitution of which for human and animal muscle has brought about profound and basic changes in our economic structure during the past century. As a result of considerable propaganda and legislation relating to power development, there is a present and constantly growing interest of the public in our existing power developments, and our potential power resources; the bearing these have on the future expansion of our modern industrialism, and their effect on our national prosperity and standards of living. As is always the case in such a situation much erroneous information has been disseminated, and many fallacious theories have been laid before the public in regard to the matter of our power resources; some of these have secured widespread acceptance, and have served to greatly obscure the true facts. As an example of this kind of thing we may refer to the great mass of misinformation published with regard to the Muscle Shoals development on the Tennessee River.

What, then, are the facts in this important matter, so far as we may determine them in the light of our present knowledge? What deductions as to the future trend of the power situation may we deduce from these facts without indulging in flights of the imagination and unfounded speculation? Let us consider these questions and see if we may not arrive at a reasonably correct visualization of the power situation as it exists in the United States at the present time; the existing trend of this situation, and its probable effect on the future. Every problem consists of certain primary elements with which are associated other elements of secondary importance. In this problem of mechanical power the primary elements are water, coal, technical skill and capital; these are the essentials and will continue to be the essentials. Our four primary elements divide logically into two groups: First, that containing the sources of power, water and coal; second, that containing the means for the application of these sources of energy, technical skill and capital. Without the first group the present day forms of mechanical power could not have been developed; without the second group they would not have been developed. It is the adaption of the inherent energy of the first group by the second to the needs of man that has produced our modern civilization and differentiates it most strikingly from the civilizations of the past.

There are sources of power other than the energy of the flowing stream and the solar energy stored in the vegetation of the carboniferous era which is released to-day when we burn coal. But such sources are secondary sources, which are either approaching exhaustion, as natural gas and petroleum, or have so far defied man's efforts to utilize their energy, as the tides.

Let us first consider our water power resources; the extent to which they have been developed; the amount remaining

undeveloped whose development can be justified on economic grounds; and the relative importance of our water power resources as a whole as compared with our present and future requirements for mechanical power. The total potential water power resources of the United States as given by the Geological Survey, including all sites capable of developing over one hundred horsepower, on the basis of power available 50 per cent. of the time, are fifty-five million horsepower, of which some 20 per cent. has so far been developed. Much of the remaining 80 per cent. consists of sites of such small capacity as to be unsuitable for profitable commercial development and operation in connection with power systems of present-day size; or sites whose remoteness from potential power markets or whose physical characteristics are such as to render their development unprofitable at the present time or in the near future. By far the greater number of our favorably situated water-power sites have been developed or are in process of development. The undeveloped potential water power remaining in the United States, which can be developed at such an investment cost as to produce electric energy more cheaply than it can be produced by steam, does not exceed ten million horsepower.

When we consider that at the present time our total mechanical power requirements, exclusive of that utilized for the propulsion of automobiles and of ships, are approximately fifty million horsepower and that for some years this has been increasing at a rate of 4 per cent. a year, we see that our available water power is capable of caring for only about 40 per cent. of our present requirements, after all available sites which can be profitably developed have been utilized and that the water power actually developed at this time supplies only 20 per cent. of our present requirements. It is greatly to be doubted if the proportion of our power requirements supplied by water power ever exceeds one fourth. From this we see how misleading is the water power propaganda so widely disseminated, declaring that "white coal" is the hope of our economic future, and the cure-all for our economic ills. Water power is to-day and will continue to be an important source of power supply, but it will always supply much less than half of our total mechanical power requirements. The vicious aspect of the present water power propaganda has been its utilization by unscrupulous promoters to induce the investing public to finance water power developments whose development was not justified on economic grounds and which could never be expected to earn a reasonable return on the investment required.

Passing to a consideration of coal as a source of mechanical power, we have shown from the preceding that 80 per cent. of our present power requirements are supplied from coal and that there is a strong probability that at least 75 per cent. of all such requirements in the future will have to be supplied from this source. We have available and known sufficient deposits of good bituminous steam coal to meet our needs for many centuries, assuming that our rate of coal consumption shall continue to increase 4 per cent. a year. However, it is very improbable that such a rate of increase will be maintained; because, with our existing birth-rate and our policy of restricted immigration, our population in the coming decades will show no such rate of increase as it has in the past; because the era of most rapid industrial expansion is undoubtedly behind us, as the productive capacity of our industries is now in excess of our domestic requirements and further expansion is dependent on the development of foreign trade in competition with the other manufacturing nations of the world; finally, be-

cause the substitution of mechanical power for human muscle will show no such rate of increase in the future as it has in the past; automatic machines will continue to be developed, but it is very doubtful if the horse power per workman in industry will show in the future a rate of increase approaching that which has prevailed since 1890.

From the beginning of the use of bituminous coal in this country, a little over a century ago, up to the present time, we have mined less than one per cent. of our known and visible supply of this fuel. Even as a great industrial nation, with an eventual population of two hundred and fifty million, which is considered about the maximum population this country can support without a decline from our present standards of living, we have bituminous coal sufficient to last over one thousand years. In addition we have vast and only partly ascertained deposits of lignites, which are low grade coals and can be burned efficiently by equipment especially designed for this purpose. Including the lignites there remains in the United States a fuel supply sufficient to last for thousands of years. While we should cease to extravagantly waste our coal supplies as has been our practice; there is certainly no danger of their exhaustion for many generations. The alarmists who constantly proclaim that we have sufficient coal for only a generation or two are very grossly misstating the actual facts. It, therefore, does not appear that any great financial expenditures are justified at the present time, having as their object the conservation of coal. The elimination of unnecessary waste would appear sufficient for the present. In the state of Pennsylvania about 12 per cent. of the better grade bituminous deposits have already been consumed; reasonable coal conservation in Pennsylvania is justified, but it is only justified to the point where the cost of the conservation equals the cost of bringing in coal from West Virginia, whose vast deposits of high-grade bituminous coals have been scarcely touched.

We come now to the second group of our primary elements and deal with the means by which the application of the energy inherent in those natural resources treated in our first group to the needs of man is brought about. The first and most important of the members of this group is technical skill, which in its most universal meaning embraces all those products of the human brain that have been developed for the utilization and adaption of the forces in nature to man's service. The United States has always been one of the great leaders in technical skill, and during the past fifteen years very great improvements have been made in this country in apparatus for the production of mechanical power, and the means employed to distribute such power from the point of production to that of consumption. Especially is this true both of water and of steam driven units for the generation of power in the form of electricity.

The hydroelectric generating unit of 1912 had an overall efficiency of around 60 per cent.; that of 1925 is 86 per cent. efficient; that is, the same stream is today capable of producing nearly half as much power again as could be secured from it with the apparatus available thirteen years ago. The improvements made in the efficiencies of steam boilers and of steam turbogenerators are even more marked. In 1913 the best of the large steam-electric generating stations in this country required 16,800 heat units to produce one horsepower-hour of energy, by 1919 this had been reduced to 14,600 heat units and by 1925 to 10,800. As a result of this great improvement in apparatus efficiency, the best plants of 1925 consume 36 per cent. less coal to produce an equivalent amount of power than was required in 1913. The most striking thing about

this improvement in steam-electric generating efficiencies is that over half of it has been made during the past two years, after many had thought such apparatus already developed to its highest economical efficiency, for very little improvement had been made in the thermal efficiency of such apparatus during the seven-year period 1916 to 1922. However, we may expect no future improvements of such magnitude in the efficiencies of power-generating apparatus, as the point has nearly been reached where the increased investment required to secure additional operating efficiency is greater than the value of the saving effected thereby. The present consensus of engineering opinion is that the maximum thermal efficiency which can be achieved in steam-electric stations of large size, without increasing the first cost beyond the economic limit, corresponds to a consumption of nine thousand seven hundred heat units per horsepower-hour of station send-out. To achieve this will require using steam pressures around one thousand two hundred pounds, and steam temperatures in the neighborhood of 800° F; an experimental installation working under these conditions has been made and is proving satisfactory. During the past few years the mercury vapor-steam cycle has been developed to the point where an experimental installation is in service; this installation has proved successful. By the use of this cycle it is believed that thermal efficiencies may be attained corresponding to a consumption of only seven thousand five hundred heat units per horsepower-hour of station sendout. This is an improvement of nearly 25 per cent. increase in efficiency over the best that may be expected from the steam cycle alone. But the development of apparatus for the utilization of the mercury vapor-steam cycle is still in the experimental stage, and it remains to be determined whether such apparatus can be manufactured at a cost where the gain in thermal efficiency will result in a saving sufficient to offset the greater investment required to utilize this combined cycle. Despite the great increase in the efficiency of steam-electric generating apparatus since 1913, the total cost per unit of station sendout is to-day 60 per cent. higher than it was then. It has been the ever-increasing unit cost of such power and the efforts of designing engineers to offset it that have resulted in the great improvement of apparatus during the past several years. The high efficiencies referred to in the preceding have been approached only in the largest and most modern central stations; the average small power plant, either industrial or public service, is still woefully and needlessly inefficient; it has been stated on good authority that it requires eight tons of coal for such small plants to produce the same amount of power that one of the large modern stations can produce from a single ton. It is in the improvement of the efficiencies of these small plants or their entire elimination that there lies the most logical field for efforts having as their object coal conservation. In virtually all such plants considerable improvement can be secured at moderate cost.

The advance in the art of the distribution and transmission of mechanical power in the form of electric current has been very rapid. From its inception in the nineties at voltages around 11,000, it developed very rapidly; until by 1912 there were extensive transmission systems in various parts of the country using voltages as high as 110,000, and transmitting power distances considerably over one hundred miles. To-day voltages as high as 220,000 are used, and power is transmitted over three hundred miles. But it is very doubtful if the voltages used or the distances power is transmitted will increase much above the maximums now in use; for the point in

such matters has been reached where certain technical limitations begin to apply, and the cost of overcoming these limitations by the means available through our present knowledge is greater than the gains to be secured by overcoming them. Despite this each year will see the transmission facilities of the country extended through the building of new lines and the interconnection of existing systems, for there is ample opportunity for expansion without the need of exceeding the voltages and distances available for commercial use. The popular belief existing to-day that in a few years the country will be covered with a network of high voltage transmission lines, supplying the entire nation's power requirements with electric power generated by mammoth hydroelectric stations or great steam-electric plants located at the coal mines, is a myth and without foundation in engineering fact. The unromantic reasons why this vision of the future will not materialize are several: First, there are apparently insuperable technical difficulties limiting the distance to which electric energy may be transmitted from the point of generation, the maximum distance to which such transmission will function satisfactorily being about five hundred miles or less; second, that there will be no economic gain in the transmission of power generated by coal beyond the point where the transmission losses equal in monetary value the cost of hauling the coal from the mine to the point of power use; third, that water power sites capable of producing as much as one hundred thousand horsepower are few. Extensive transmission systems exist to-day and many such systems are interconnected, such interconnection being for mutual assistance in time of breakdown or for the exchange of power, either generated or used in the territory adjacent to the point of interconnection. Such interconnections are not for the purpose of through transmission of electric power, and the idea of power being transmitted across the continent by the interconnection of all the intervening power systems is a physical impossibility.

The most comprehensive schemes under discussion to-day having as their objective the conservation of coal are "superpower" and "giant-power." The former has been worked out principally with regard to the requirements of the northeastern industrial section, and the latter with respect to the needs of the state of Pennsylvania alone. While both these plans have many things to commend them, it is doubtful, in view of the great magnitude of our remaining coal deposits, whether there is economic justification for the carrying out of either at any time in the near future. Certain features of both plans which can justify their adoption by their ability to earn a reasonable return on the investment required for their carrying out are worthy of immediate adoption. Other features calling for large investments of capital, and which do not show probabilities of being able to earn a return on such investments should be discarded for the present. In view of what technical skill has accomplished, it is certain that the future will see still further advances by man in his harnessing of natural forces to his service. This would appear to be one of many plausible arguments against the present adoption of conservation measures involving large expenditures of capital; unless such measures are capable of earning a reasonable return on the investment required to make them effective.

We pass now to the consideration of our final primary element, capital. The rôle played by this element in modern power development has been one of ever-increasing importance; this results from the constant increase in the magnitude and scope of the projects undertaken.

Large scale operations, such as characterize present-day power developments, call for great financial resources and the ability to attract capital. As a result all such undertakings are promoted and controlled by powerful financial groups; a small number of such groups completely controlling the present power situation in this country. For the past several years the financial activities in connection with the power industry have centered mainly in the bringing about of extensive consolidations of existing properties; thus bringing under one management the power supply of extensive areas. Such consolidations have been marked by a definite policy of inflated capitalization at figures considerably above the value of the physical property involved. Such a policy, while not inherently vicious, is fraught with considerable risk to the public; as there is always the chance and usually the probability that in the future an effort will be made by the controlling interests to have rates fixed on the basis of the capitalized value of the property, rather than on its actual physical value, this latter being very difficult to determine accurately. The highly successful carrying out of such inflation policies in the past is what has attracted certain financial interests into this field, where the apparent earnings are usually nominal, but the promoters' profits often very large. The results achieved by the regulatory bodies of the various states having under their control the public utilities have not so far been very encouraging; while there are notable exceptions most of these commissions have functioned in a manner unsatisfactory to both the power interests and the public welfare. The great weakness of such regulatory bodies is their ignorance on technical matters, their members as a rule being lawyers or professional politicians, engineer members being the exception, whereas they should be the rule on such commissions. Suitable and just regulation of the power industry by competent state commissions is the only fair and equitable method of dealing with this aspect of the power situation. Power development calls for large amounts of capital and the assumption of great risks by the promoters, and such undertakings should render a fair return to those having the vision and courage to undertake them. On the other hand, in view of the monopolistic nature of the power industry, great care should be taken to see that the public and the small investor are not exploited.

We may summarize the preceding by stating that our water power developments at present furnish only one fifth of our total power requirements and there seems little prospect of this ratio being much increased; that we have sufficient coal and lignites in this country to last for several thousand years, and no coal conservation scheme is justified unless it is able to earn a fair return on the investment required to carry it out exclusive of the conservation feature; that technical skill has made great improvements in recent years in the efficiency of power generating apparatus and there is no ground to believe that the ultimate has yet been attained in this field; that the present financial trend of the power industry is such as to demand sane and just regulation in order to protect both the public and the power companies. It is hoped that the preceding may shed some light for the reader on the existing power situation in the United States and its apparent trend.

DR. JAMES F. NORRIS

PROFESSOR OF ORGANIC CHEMISTRY AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, PRESIDENT OF THE AMERICAN CHEMICAL SOCIETY FOR THE FIFTIETH ANNIVERSARY MEETING HELD LAST MONTH AT PHILADELPHIA.

THE PROGRESS OF SCIENCE

THE FIFTIETH ANNIVERSARY MEETING OF THE AMERICAN CHEMICAL SOCIETY AND THE PROGRESS OF CHEMISTRY IN AMERICA

By Dr. E. E. Slosson

Director of Science Service, Inc., Washington, D. C.

Copyright, 1926, Science Service, Inc.

The first impression one got from the meeting of the American Chemical Society held in Philadelphia from September 6 to 11 was that chemistry could be called "the science of short cuts." The word heard most frequently from the lips of the rubber chemists was "accelerators," and all the other chemists talked about the same thing in other words. At the opening session Irénée du Pont said that the use of the new chemical accelerators in the vulcanization of rubber had increased the mileage of tires in the last ten years enough to send 2,500,000 automobiles around the world. Such is the outcome of the accident of the Yankee inventor Goodyear, when he spilled his mess of rubber and sulphur on a hot cookstove and picked it up improved. Another new speeding-up process is the spraying of dissolved guncotton as a substitute for the old-fashioned way of painting with a brush and patiently waiting for it to dry. Mr. du Pont tells of one manufacturer of automobile bodies who by the use of such lacquers has saved five million dollars a year which he would otherwise have had to spend for additional paint shops and drying equipment.

But Mr. du Pont's scientific imagination is not confined to such material things as accelerators and lacquers and dyes. He hopes to reduce or eliminate the time now wasted in sleep. If sleepiness is due to the accumulation of poisonous substances generated by muscular and nervous activity, might these not be more rapidly removed or neutralized by the proper catalytic chemicals than by the slow restorative process of sleep? He also calls upon the chemists to devise drugs that will stimulate the brain without stupefying it; that will exhilarate without subsequent depression; that will make all men supermen; and that will reform the character and improve the disposition by correcting the sourness and crabbedness which as we know are often due to the secretions of disordered glands. "May we not expect," he concludes, "that by injecting proper compounds into an individual we can make his character to order? If study and experiment can reach this result it would seem to be a short cut to the millennium."

Short-cuts likewise formed the main theme of Prince Piero Ginori Conti, senator of the Kingdom of Italy, in his address on "The Development of the Chemical Industry in Italy." He told how the waterfalls of the Italian mountains, formerly esteemed only for scenic value, are now being harnessed to dynamos and employed in making various vegetable products, which used to be prepared by the tedious processes of Nature. Acetic acid, once made by the vinegar plant, is being made by the hydroelectric plant at Villadossola. Wood alcohol, recently renamed methanol, comes now

Photograph taken at Philadelphia. From Wide World Photos

DR. EDGAR FAHS SMITH

PROVOST EMERITUS OF THE UNIVERSITY OF PENNSYLVANIA, AND FOR THIRTY-TWO YEARS PROFESSOR OF CHEMISTRY AT THE UNIVERSITY. THE PHOTOGRAPH SHOWS DR. SMITH RECEIVING THE PRIESTLEY MEDAL AT THE RECENT ANNIVERSARY MEETING OF THE AMERICAN CHEMICAL SOCIETY.

from coal instead of wood. Camphor is made synthetically in Italy instead of extracted from the tree in Japan. Formaldehyde, the familiar disinfectant, is also made artificially. The camphor can be used for the making of celluloid for movie films, and the formaldehyde, added to the casein of milk, gives a similar plastic material. The factory is outstripping the worm in the manufacture of silky fiber, and Italy stands second only to the United States in this industry. Eleven large factories there are now engaged in making synthetic silk and as many more are being erected. Some 13,500 tons of the new textile material were made by Italian factories last year. The Italians are indebted to the bounty of Nature for the hot springs carrying boric acid, but they have made a unique utilization of them in employing their heat for the running of steam engines. One of these volcanic power plants produce 7,500 kilowatts of electric current.

After listening to this story of the surprising achievements of synthetic chemistry in Italy and the United States, it was appropriate that the session should be brought to a close by Paul Sabatier, dean of the faculty of Toulouse University and Member of the French Academy, who told us how the traditional barrier between the animate and inanimate realms was finally demolished by the researches of his renowned teacher, Marcelin Berthelot. Sabatier was the assistant of Berthelot at the Collège de France when he performed the epoch-making experiment of preparing various organic compounds, such as benzene and alcohol, from the primary inorganic elements, carbon, hydrogen and oxygen. The outstanding achievements of Berthelot will be celebrated in France on the centenary of his birthday next year and permanently commemorated by the establishment of a "House of Chemistry" in Paris.

Ice cream made from crude oil was one of the many marvels forecast by Professor James F. Norris, president of the society. Edible fats, the same as those in vegetable and animal foods and other fats equally nutritious but not found in nature can be obtained by breaking up the molecules of mineral oil and rearranging the atoms to form new compounds.

This cracking process has been applied to petroleum for many years to obtain a larger yield of the gasoline distillate, but the investigations recently carried out by the Petroleum Institute have shown that it is possible to attach oxygen to the cracked molecules and so produce alcohols and acids of all sorts. Aromatics, flower perfumes, fruit flavors, drugs and dyes in infinite variety may be made by such methods.

This suggests that petroleum which has hitherto been used for fuel and lubricating may be found in the future to be even more valuable as a source of substances for which man has been dependent upon the chance bounty of nature. Glycerin, which is now obtained from the decomposition of soap fats, can be produced from petroleum, and transformed into nitroglycerin for dynamite. Synthetic plastics like rubber and bakelite may also be manufactured from the same raw material. As one of the speakers remarked, it is unfortunate that we should come to realize the possibilities of petroleum only now, when the Government Oil Commission announces that the known oil reserves of the United States will last only six years at the present rate of consumption.

But Dr. Norris has his answer to that objection, for he foresees the utilization of the limitless stores of energy confined within the atom, as manifest in radium.

"When I saw not long ago in the laboratory of Dr. S. C. Lind a tiny drop of a colorless oil that had been formed from methane—the chief constituent of natu-

STATUE OF DR. EDGAR FAHS SMITH

STANDING ON THE GROUNDS OF THE UNIVERSITY OF PENNSYLVANIA NEAR THE LABORATORY OF CHEMISTRY, WHICH DR. SMITH DIRECTED FOR THIRTY-THREE YEARS. DR. SMITH IS SHOWN STANDING BY THE STATUE. ON THE LEFT IS ITS DONOR, MR. JOHN C. BELL, FORMERLY ATTORNEY-GENERAL OF PENNSYLVANIA AND A TRUSTEE OF THE UNIVERSITY.

ral gas—as a result of the action of this form of energy upon it, I felt a new era in chemistry had dawned," Dr. Norris said. "That droplet meant a supply of combustible liquid to run our automobiles when petroleum is exhausted. We can make methane from carbon and hydrogen when the supply of natural gas fails us. The sun will always be able to convert carbon dioxide into a form from which we can get back carbon."

Dr. G. J. Esselen, speaking in behalf of cellulose in this "Symposium on Future Trends in Industrial Chemistry," demurred to the suggestion of synthetic ice cream and expressed a preference for the old-fashioned method of feeding the cellulose to a cow. But in his own field Dr. Esselen was quite as radical in his prophecies as Dr. Norris. He even went so far as to surmise that the synthesis of cellulose may some day be accomplished in the factory as it is now in the field from the free raw materials of air and water.

Cellulose, which is the woody stuff of trees and other plants, now requires months or years to grow, but if the chemist once learns how to make it he may turn out a purer product in a few days or hours. Already the first steps toward this achievement have been taken. It has been found possible to make glucose artificially by the action of ultra-violet rays on water and carbon dioxide, that is, on "soda-water." It is easy to convert cellulose into glucose, and if we only knew how to reverse this reaction synthetic cellulose would be possible, though whether it would be profitable or not remains to be seen.

Of more immediate interest was the fact, pointed out by Dr. Esselen, that the artificial fibers of cellulose, such as rayon, are being strengthened by new processes and may eventually be made as strong as cotton or stronger. These synthetic fibers are made cheaply from wood pulp and since they have the luster of silk they have within a few years come to be used in twice the quantity of natural silk. But they have hitherto been unable to supplant either silk or cotton because the artificial fibers are weaker and more fragile, especially when wet. If this deficiency can be overcome the synthetic fibers will be a stronger competitor of the natural and this suggests the question whether the slogan "cotton is king" will hold in the future as it has in the past.

Wood pulp is now being obtained from southern hardwoods and no longer exclusively from northern softwoods. Perhaps still faster-growing trees or other plants may be the source of cellulose in the future. Dr. J. G. Lipman, in discussing the possibility of supplanting cotton as the chief textile plant, pointed out that this would effect a revolution in American agriculture, for cotton is a billion dollar crop and the forty-nine million acres now growing it would have to be devoted to other produce.

Dr. Charles H. Herty also prophesied that the rapid expansion of rayon would vitally affect farm and factory. An old and seemingly established industry, varnish, has been revolutionized within the last few years by the rapid spread of the use of dissolved cellulose in lacquers for automobiles and the like.

The most sensational and possibly the most important of the discoveries made public during the week was the announcement before a large audience at the Academy of Music by Dr. Irving Langmuir, of the General Electric Company of Schenectady, of a chemical combination that produces greater heat than any hitherto known.

For over a hundred years the highest heat attainable by combustion was that produced by the burning of hydrogen in an atmosphere of oxygen. But Langmuir has found it possible

THE PRESIDENT AND THE SECRETARY OF THE AMERICAN CHEMICAL SOCIETY

DR. JAMES F. NORRIS, PRESIDENT OF THE SOCIETY FOR THE PHILADELPHIA MEETING, IS ON THE RIGHT. ON THE LEFT IS DR. CHARLES L. PARSONS WHO HAS BEEN SECRETARY FOR THE PAST TWENTY-SIX YEARS.

to get a higher temperature by the unprecedented process of burning hydrogen in an atmosphere of hydrogen. In the oxyhydrogen blowpipe, commonly used for welding or the limelight, two atoms of hydrogen united with one atom of oxygen to form a molecule of water. In the new Langmuir blowpipe two atoms of hydrogen simply unite with each other to form a molecule of hydrogen.

The novelty of the process consists in the possibility of producing a stream of hydrogen gas in the form of single and separate atoms instead of paired atoms, in the form which hydrogen has been hitherto handled. The coupled hydrogen atoms are divorced by passing a stream of the gas through an electric arc. The apparatus is simple, and looks like the ordinary blowpipe that you see used in welding or cutting steel on the street car track. It is held in the hand and the point of the flame directed on the metal while the head of the operator is enclosed in a helmet to protect the eyes and face from the intense light and heat.

A stream of hydrogen from a small copper tube is driven between the tips of the two tungsten electrodes and projects a double flame several inches long. The inner flame consists of atomized hydrogen burning in molecular hydrogen, while surrounding this is a flame of molecular hydrogen burning in air.

A tungsten wire stuck into the tip of the inner flame melts and drops off like an icicle in a gas jet. Now tungsten is a metal so refractory that it required many years of experimentation to find a way of getting it sufficiently softened so that it could be drawn into filaments for electric lamps. Its melting point is over six thousand degrees Fahrenheit, so the temperature of the flame of atomic hydrogen is doubtless more than seven thousand.

If the blowpipe is turned upon the tip of a cone of aluminum, the refractory ingredient of clay and porcelain, this melts down like a tallow candle in a Bunsen burner. If a sheet of steel or other metal is rolled into a tube the seam can be welded without solder by simply running the blowpipe along the joint. When the flame plays on a plate of chrome steel it leaves a string of puddles in its track.

The heat is higher than that of the familiar oxy-acetylene blowpipe though not so high as in the electric arc itself. Dr. Langmuir suggested that we may in time get rid of the rattle of riveting which annoys the neighborhood when a skyscraper is being constructed, and the welded joints of the steel frame would be stronger since no holes need be bored in it.

A further advantage of the new flame is that the metals heated by it are not oxidized, since they are completely enclosed in hydrogen gas. This makes it possible to weld such light metals as aluminum and magnesium, which when heated in air fall into white powder.

Professor H. S. Taylor, of Princeton, supplemented this address by a demonstration of the activity of atomic hydrogen in the cold. He breaks up the pairs of hydrogen atoms by the use of the mercury vapor lamp, familiar to us from its ghastly glow in photographic studios. In this the mercury atoms are "excited," that is, put into a peculiarly active state by the electric current. This activation consists in loosening up an electron, driving it to an outer orbit of the atom, something like what would occur if our solar system should be dislocated by suddenly shifting Venus into the orbit of the earth. When one of these excited mercury atoms comes into collision with a pair of hydrogen atoms it is apt to break their union, and the disrupted atoms of hydrogen seize on the atoms of any other elements at hand and form new compounds. This theory may explain the mystery of what have been called "catalytic action" and the "nascent state."

Synthetic rubber is not a success and a shortage in the supply of natural rubber seems imminent. Such was the consensus of opinion at the raw rubber symposium of the American Chemical Society. Experts from Canada, England, Holland, Germany and Brazil as well as from the leading American rubber companies were in attendance at the session and none of them was able to point out definitely any way of increasing the rubber output of the world until the trees now being planted come into bearing, which will require about seven years.

Dr. H. N. Whitford, of the Rubber Association of America, presented a thorough survey of all known sources and came to the conclusion that the demand for raw rubber will increase at the rate of five per cent. a year for the next five years and the existing plantations could not meet the deficiency, even if the restrictions are removed. If crude rubber rises to sixty or eighty cents a pound this will undoubtedly stimulate the search of South America and Africa for

PROFESSOR RICHARDS AND DR. REMSEN

ON THE LEFT IS DR. THEODORE W. RICHARDS, PROFESSOR OF CHEMISTRY AND DIRECTOR OF THE GIBBS MEMORIAL LABORATORY OF HARVARD UNIVERSITY. DR. IRA REMSEN HAS BEEN PROFESSOR AND PROFESSOR EMERITUS AT THE JOHNS HOPKINS UNIVERSITY SINCE ITS OPENING IN 1876 AND WAS PRESIDENT OF THE UNIVERSITY FROM 1901 TO 1913. THE PHOTOGRAPH WAS TAKEN AT PHILADELPHIA AFTER HONORARY MEMBERSHIP HAD BEEN AWARDED TO DR. REMSEN AND DR. RICHARDS.

wild rubber, but Dr. Whitford suspects that the number of untapped trees in the forests has been exaggerated and that the maximum output of wild rubber may already have been reached. Higher cost of Para rubber will bring in other rubber-bearing plants, such as the castilloa and guayule, and this with the increased use of reclaimed rubber may prevent famine prices from prevailing in the near future, and enable the poor man to keep his car.

Why rubber trees do not grow under the shadow of the American flag, while they flourish so profitably under the British, Dutch and Brazilian flags, is a mystery that the botanist alone can not solve. It is a question rather for the statesman and financier. There is a native shrub, the guayule, growing wild on the deserts of California and Arizona, which may be made to contribute to our economic independence in this essential commodity. The Carnegie Institution of Washington and the Continental Rubber Company have studied its possibilities as a rubber producer, and the experiments carried on by that company for the last fourteen years were reported in a paper by Dr. W. B. MacCallum. The guayule requires five years to grow and then is only two feet high and weighs a pound dried, but it contains a high percentage of rubber. This is carried in scattered solid particles, not as a milk as in the Brazilian rubber tree, so instead of getting the rubber by tapping, the shrub has to be cut down and ground up and the rubber extracted. Millions of seedlings have been grown and from these ten plants have been selected to provide stock, from which it is hoped to start a plantation capable of giving as good a yield as the rubber trees of Malaya and Sumatra.

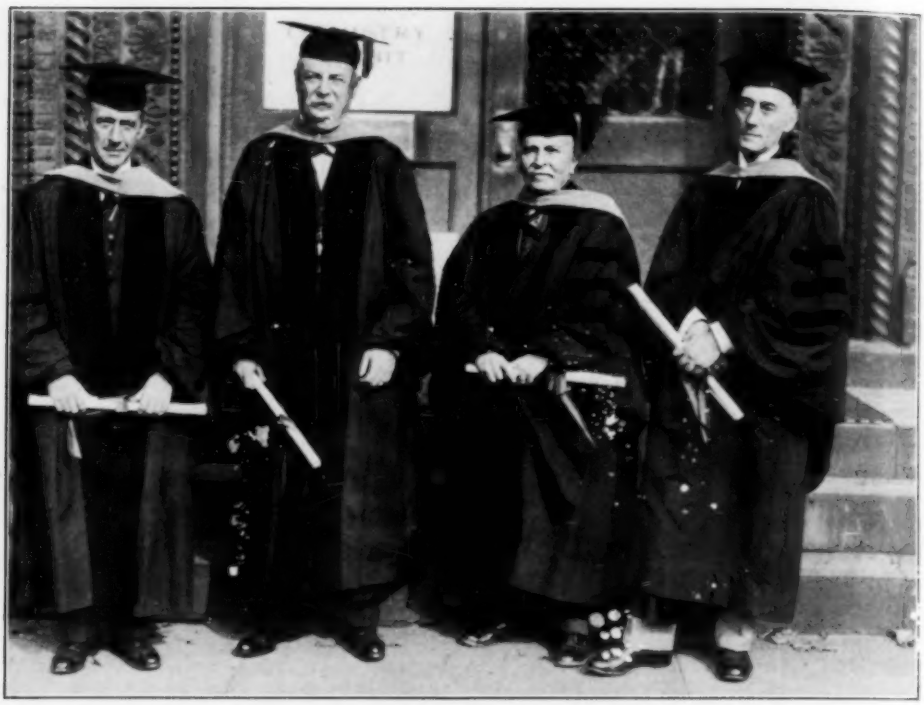
How Germany suffered during the war from her deprivation of rubber and the inadequacy of artificial substitutes was first revealed in a paper by Dr. Richard Weil, of the Continental Caoutchouc and Gutta Percha Company of Hanover. Several laboratory methods for making synthetic rubber were known before the war but none of them proved satisfactory on a large scale in this emergency. One process starts from starch, but the potatoes which might have furnished the starch were sorely needed for food. Another process uses coal and lime as the raw materials, combining them to make calcium carbide and from this acetylene gas. By this process 2,350 tons of synthetic rubber were manufactured during the war, but it cost five dollars a pound and was inferior to the natural, except for hard rubber. The automobile tires made from it gave out after about 1,500 miles' service and for inner tubes it would not do at all. Dr. Weil concludes:

"If the use of rubber continues to increase at the same rate, it may be assumed, according to expert opinion, that in a few years there will not be sufficient area under cultivation to satisfy the increasing demand. New plantings would not become productive until 1934. Old plantations will become exhausted, so that it may be expected that the price for raw rubber for the next ten years will be relatively high."

William C. Geer, vice-president of the Goodrich Company, agrees that the artificial product is inferior, inelastic and expensive, "so I am convinced that the world has little to expect, and the planters nothing to fear, from synthetic rubber."

Samples of artificial rubber and of various sorts of rubber substitutes made from rape seed, soy bean and other oils were exhibited to the symposium, but they were regarded more as laboratory curiosities than as serious competitors to the product of the tree.

J. W. Bicknell, of the United States Rubber Company, which has the most extensive plantations in the world, all



DISTINGUISHED FOREIGN CHEMISTS

ON WHOM THE UNIVERSITY OF PENNSYLVANIA CONFERRED HONORARY DEGREES AT THE RECENT MEETING OF THE AMERICAN CHEMICAL SOCIETY. FROM LEFT TO RIGHT THEY ARE SIR JAMES COLQUHOUN IRVINE, PRINCIPAL OF ST. ANDREWS UNIVERSITY; GIONORI CONTI, SENATOR OF ITALY; PROFESSOR PAUL SABATIER, UNIVERSITY OF TOULOUSE, AND PROFESSOR ERNEST COHEN, UNIVERSITY OF UTRECHT.

in foreign territory, explained that the planters could increase their output, as the dairymen had improved their cows, by picking out the best milkers and breeding from them. Records of the yield of individual trees in large numbers for several years showed that half of the trees produced three fourths of the latex and that this characteristic was continuous and hereditary.

Hunting for highly important needles in haystacks of flesh is the kind of thing Gabriel Bertrand, of the Pasteur Institute, Paris, has been doing for many years. He told the medical chemists of his discovery of the apparently great importance of the common metals nickel and cobalt in the human body, though there is not enough of either present in a full-grown man to plate the hands of a wrist-watch. Until he began his researches it was not even suspected that living flesh contained these elements, and he has shown them to be present in almost infinitely small quantity: from one to five parts in ten million is the order of magnitude he found.

But the tiny amounts of nickel and cobalt that we have seem to be absolutely necessary to life, for they somehow act with the insulin produced in the pancreas to prevent the deadly disease diabetes. M. Bertrand found that the pancreas contains much more nickel and

cobalt than do other body tissues, and he found also that when tiny doses of these metals were given to animals suffering from diabetes their recovery was greatly speeded up. He even found that beneficial results followed from doses of nickel and cobalt given to diabetic animals without the use of any insulin at all. These experiments may point the way to improved methods of treating diabetes, especially in the number or size of the somewhat disagreeable insulin injections.

Motion pictures of the minute particles of rubber dancing in the latex tapped from the rubber tree attracted the largest audience of the society on the closing day. This was the first time that such a feat has been accomplished, for the globules of the emulsion are far too small to be seen with the naked eye and the latex looks like cow's milk, a plain white liquid.

But in the micro-movie camera, devised by Dr. Ernst A. Hauser, of Berlin, droplets of caoutchouc suspended in the sap appear as irregular tailed spheres, shaped like commas, and are seen to be in incessant motion, darting hither and thither, colliding and rebounding, so that one would think he were looking through a lens at a drop of water full of animalcules. But they are not living cells and their agitation is due to the jostling they get from the molecules of the liquid, which are kept in motion by the heat: what is called the "Brownian movement" from its discoverer.

In the drop of rubber milk projected on the screen they were stirred up or stopped by a glass filament drawn to a point too fine to be seen, and guided by the hand of Frau Hauser, who has a more delicate touch in such microscopic manipulations than her husband. When she punched a hole in one of the droplets the rubber oozed out through the skin as a viscous liquid. The rubber particles looked as large as baseballs on the screen but really are a ten thousandth to a fifty thousandth of an inch in diameter.

A new method of treating the rubber latex that promises to be of great commercial importance was described by Philip Schidrowitz, the London rubber expert. The customary method is to coagulate the latex with acid which throws it out of solution like curdled milk. Then the mass is mixed with sulfur and other desired ingredients, shaped and heated. The heating combines the raw rubber with the sulfur and makes it solider and less sticky. This process is called "vulcanizing." But Dr. Schidrowitz treats the fresh latex as extracted from the tree directly with sulfur, without previous coagulation. This process of vulcanizing the latex is said to be easier and quicker and the finished rubber is stronger, more durable and more uniform.

Fields of gorgeous dahlias may replace the soberer beets as the mainstay sugar crop of this crop of this country, and the sugar made from their tuberous roots will be half again as sweet as the variety now on the market. W. C. Arsem told of the intention of the interests with which he is associated to start growing dahlias on a large scale for the purpose of manufacturing this super-sweet sugar, known as levulose. The dahlia roots do not contain any levulose, but they are largely made up of inulin, a starch-like stuff that can be turned into levulose by treatment with weak acid. The process outlined by Mr. Arsem sounded almost as economical as the packing-house procedure which makes use of all the pig except his squeal. After yielding its main burden of sugar the left-over sap is to be fermented for commercial alcohol for automobile fuel, and the small amount of pulp in the roots will be worked up into paper or building material.

Another of the dreams of the ancient alchemist, besides the transmutation of metals, seems likely to be realized, for the discovery reported by J. O. Ralls reminds one of the love philter, which has figured so frequently in tale and drama. It has been learned that the characteristically feminine reactions, both physiological and emotional, are influenced by a substance produced in the female sex glands, and that extracts containing this chemical compound can induce normal sexual behavior in female rats that have been rendered sexless by a surgical operation. Dr. Ralls and his associates have succeeded in obtaining extracts of high purity and great power, and hope eventually to solve the riddle of the exact composition of the sex hormone.

Crude codliver oil makes happy hens. This may make many of us, with unhappy childhood memories still sticking to our palates, more sure than ever that hens have no sense. Yet Dr. A. D. Holmes, in a series of experiments on the hatchability of eggs and the livability of chicks mothered by hens on a diet containing codliver oil, showed conclusively that within limits the more they got of the nasty stuff the more and better eggs they laid, and the more and healthier were the chicks hatched from them. This was due, he said, to the high vitamin content of the oil. Moreover, when subjected to the crucial test at the table, neither eggs nor chickens were tainted with any noticeable flavor.

To prevent goiter, swallow sea-weed. This is not the medieval prescription of a "herb wizard," but the ultra-modern advice of J. W. Turrentine, government expert on the chemistry of the hundred-foot-long kelps of Pacific coast waters. It is based on the fact that these sea-plants are rich in iodin, shown by recent medical research to be necessary for the prevention of the disfiguring neck disease. Dr. Turrentine states that because the iodin of sea-weed is held in a nearly indigestible gelatin-like substance, it is released into the system very slowly to do its beneficial work, whereas the easily soluble iodin salts commonly employed are quickly eliminated from the circulation, though they may work mischief by causing skin eruptions before they do so. Dried kelp ground up into flour is the form in which this marine vegetable iodin is to be administered. One can get kelp-flour tablets if he wants to take his medicine straight, or he can get kelp-flour candy or biscuits if he wants to take it under a pleasant camouflage.

This having been the fiftieth anniversary of the founding of the American Chemical Society, a program of unusual scope and character had been prepared. There were 392 papers listed for the meeting, each presenting some new contribution to the science, and it was necessary to hold sessions of several sections simultaneously to get them read. Considering in addition the attractions of the Sesqui-Centennial and the hospitality of the Philadelphians, the chemists needed injections of the proposed anti-sleep potion to carry them through the week.